GAS JOURNAL

LIGHT ⁘ HEAT ⁘ POWER ⁘ BYE-PRODUCTS

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VOL. CLXXXII. No. 3396.] WEDNESDAY, JUNE 20, 1928. [80TH YEAR.

The Meeting of the Institution at Cardiff.

CARDIFF has installed itself in the affections of the members and prominently in the annals of The Institution of Gas Engineers. It was entirely a wonderful and successful week that was passed through by an attendance of members and their ladies that, to the best of our long experience, surpassed any annual meeting in the provinces. To what was it all due? In the first place, our friend Henry Dacre Madden, M.Inst.C.E., is likewise the friend of everybody who knows him. He cannot be otherwise; nature has endowed him with those attributes which make men like him, and which make him like his fellow-men. Then a second factor in success was that the Cardiff Gas Company, of which he is the chief executive officer, is administered by a Chairman (Mr. L. G. Williams) and Board of Directors who are strong supporters of co-operative effort—men who believe that from the collaboration of brains the best possible results are derived whether it be in the scientific and technical part of our work or in the purely commercial. Therefore, when Mr. Madden was elected to the Presidency of the Institution, his Chairman and Directors assembled as one man at his back as supporters. His election was an honour to them and to their Company; and so they were going to be in it to the end. And they were. The professionals of our industry will not readily forget their generosity; and they will be all the more glad because Mr. Madden was the man for whom initially it was all done. Then, thirdly, the Lord Mayor of Cardiff (the Rt. Hon. A. J. Howell, J.P.), despite his exigent duties last week in receiving the Prince of Wales to open the Welsh National War Memorial in Cathays Park, could not let the occasion pass without according the Institution a civic reception. And, fourthly, but by no means last, the gas engineers and managers of the Principality deemed it a great honour that one of their leaders should have been the elected official Head of the Institution and of the gas profession; and they wanted their English, Scots, and Irish visitors to take away good impressions of the real soul of Wales, its people, and its beautiful scenery. The Reception Committee which they formed, and who worked with the single intent of success, was a good and valuable conception, and did much in all plans and details to gain their objective.

The brilliance of the weather throughout the week was simply symbolic of the whole proceedings, which were of more than usual interest. Somehow or other the Institution seemed on this occasion to have got away from the old stereotyped forms which have done duty, albeit changing times, for the past two or three generations. Even little incidents make departures from the humdrum. The appearance of friends from abroad, and a few words from them, make a difference. Our old friend Will Thorne, M.P., as juvenile as ever, notwithstanding the flight of years since he was a gas worker, showed us the human tie there is between employer and employed, and how that tie can be made of mutual benefit by co-operative methods. He is a man who with advancing years has learned that statesmanlike negotiation is of more avail than militant tactics; and he believes that the best interests of all engaged in an industry can be served by working hand in hand. Would that all employers as well as workers' representatives saw the same thing. Then among the incidentals of more recent years which lend variation to the programme is the presentation of the H. E. Jones "London" Gold Medal, which was on this occasion happily and rightly conferred upon Mr. Thomas Carmichael for his delightful and instructive paper of last year on "Carbonizing Economics as Exemplified by Results and Modern Working Costs at the Portsmouth Gas-Works." Talking of gold medals, among the incidents of the meeting was the presentation by the Company's workmen of a gold cigarette case and matchbox to the President. It was a very happy idea and event, and gave as much delight to the givers as to the recipient. It was grand evidence of the bond that exists between the chief and his men. Another item was the presentation of the diplomas to the men who have won them under the Education Scheme. In this connection there is one thing we should like to say. The winning of a diploma is an honour. It shows the capability for application, for perseverance, for the pursuit of those things which are valuable in professional life. But it is not the end. There is much beyond. The gaining of the diploma in an industry such as that of gas manufacture and supply is only the beginning of what is necessary. Look at the researches and the new knowledge conveyed in papers year after year at the meetings of the Institution, and they tell us plainly how deficient we are in what we ought to know, and what we must know, if we are to make progress. The holding of a diploma is a guarantee of several things, and it gives us confidence in the holder. But the same traits that have gained that distinction must be carried on day by day and through professional life in order to keep the holder abreast of the knowledge required in a many-phased industry such as that of gas manufacture and supply.

The papers and the reports which were presented on this occasion (some on new subjects) were varied. Certain of them were weighty with scientific and technical fact; others—such as the report on gasholders—promise interest for the future. The paper by Mr. W. H. Johns, of Swansea, was an excellent engineering one with plainly stated working results, which showed that coal, as well as plant and the perfection of supervision, has a part in the realization of the highest results. There was the contribution by Mr. Stephen Lacey, B.Sc., Assoc.M.Inst.C.E. When Mr. Lacey speaks to us on any problem bearing upon distribution, he commands our respect, for we know we are listening to a master of the subject. The present occasion was no exception. The science for application in the defined circumstances was there; and Mr. Lacey has earned our gratitude on this as on other occasions for what he has done for the profession in this important part of their operations—the keeping of the distribution part of the plant up to modern requirements, with a margin for prospective demand. The paper by Mr. H. C. Smith, M.Inst.C.E., of Tottenham, was in effect a practical supplement to Mr. Lacey's contribution; for it was definitely an illustration of the application of science to the problem of distribution in these times of vagarious flights in the demand for gas. As we read Mr. Smith's paper we are persuaded that the

more difficult side of a gas engineer's task is in keeping his distribution system rather than his productive plant in consonance with the demand of his area. The latter can be planned, through its variety and capacity, for the quantitative change to meet circumstances; but the distribution plant, once placed underground, has to meet fixed conditions, save the variability realizable by boosting, which is limited by the big variations of demand. However, Mr. Smith makes a telling point when he, in the winding-up of his story, of how he supplemented his distribution capacity, tells us of the small cost per annum per consumer that this has meant in providing sufficiency, quantitatively and in pressure, to each consumer. As he says, maintenance would cost much more; but "maintenence" does not end at quantity and pressure, as inspection of consumers' appliances has shown. The passing from these matters—interesting, instructive, and important though they be—to the paper by Mr. S. Barker Johnson, of Colombo, was like passing from the study of a text book to the reading of a novel. It was a new experience to have this account first-hand from a fellow-professional carrying on his work under eastern conditions, which are as dissimilar from those in the homeland, through atmospheric circumstances and psychology of the people, as chalk is from cheese. More honour therefore to the men who carry on the work in other lands with such success that they create demand such as Mr. Johnson has promoted in Colombo.

We will say no more as a preface to the summary and the full report of the proceedings at a remarkable annual meeting. It is the last we anticipate under the old order of things; it was the one which brings to a close the year in which all the collar work was done in connection with the petition for the Royal Charter and the revision of the by-laws, including that long drawn-out contest for extending the area of technical qualification for membership of the Institution. With all that work the name of Henry Dacre Madden will be associated; but the honour of the conferment of the Charter will be in the year of the Presidency of Mr. John Terrace, whose Vice-Presidency has been marked by a devotion to the junior technical associations which, we think, must be a record. To him, as an almost life-long friend, we offer our heartiest congratulations upon his accession to the highest office in the profession, and our best wishes for the richest success.

Our Potentialities and their Development.

THE address which the President of The Institution of Gas Engineers (Mr. H. D. Madden, M.Inst.C.E.) delivered at Cardiff yesterday week was not of great length, but its substance was valuable, and in it are rich veins of thought which should stimulate our work for the future. He glances backwards, makes comment upon the present position, and directs our minds into channels which should end in the materialization of those great potentialities with which our industry is undoubtedly richly endowed. Those who well and truly laid the foundations of the industry, and helped to develop it up to within the last few decades, had little knowledge of what was in store for it. Their horizon was limited by the information they possessed; but that information has since grown enormously—so much so that scientists and technicians are tumbling over each other in making exploration into some of those many little known avenues which are found in what the President aptly calls the "constructive distillation" of coal, as distinguished from its destructive distillation, which, to his mind, is a term better applied to the crude burning of coal, and the wasting of its richness by dissipation of the products into the air. However, as the President shows, it is a long history that has brought us to the present state of affairs in carbonization. In the address we have recalled to mind the names of men who were pioneers in the work, and those of men who were outstanding within times in which many of us have lived and moved. They all made their contribution to the construction of the road which has led to greater and greater achievement, and along the extension of which we now see possibilities—some already beginning to take definite shape, some still in amorphous condition, and others we visualize from the knowledge which research is presenting to us.

The line of thought which we find uppermost in the address is the one we are disposed to pursue; and it is the one that obviously holds the greatest attractions for the President. In the midst of our daily round and common task, it is, as he says, well to pause and consider sometimes what our industry stands for, what it has achieved, and at the same time endeavour, with a wide view, to ascertain what the future has in store. To put it in a different way: With what breadth of vision can we visualize for our business a continuous and increasing development? "Increasing development" depends on trading as well as production; but perhaps we are willing to give greater welcome to those who are studying carbonization with a view to enhancing its yield, than we are to those who are trying to reduce our claim, by efforts to appropriate our business, to being the largest suppliers, next to the coal industry, of heat units in this country. That position the gas industry is going to maintain, or rather it will do so if it goes the right way to work. Fuel questions are not, of course, limited to what we do in the gas industry. Fuels, processes, and problems are variegated. But as producers of gaseous and smokeless fuel, with valuable secondary products, our experience in point of time, quantity, and in different circumstances is unrivalled; and we must see that the position we have attained is defended and improved upon by our participation in all scientific and technical work which is opened up in various quarters. We must not by any neglect lose position or fair control in the direction of this work; and we shall have to rely upon the Institution to keep the industry to the fore in this particular. It is only necessary to look round and observe the composition of the bodies who are taking prominent part in the consideration of the country's fuel problems to see the importance of the gas industry taking its rightful place as an influential leader in their discussion and solution. The membership of the Institute of Fuel, for example, includes those scientifically or technically concerned in the applications of fuels of all descriptions. The Fuel Section of the Society of Chemical Industry incorporates chemists from many spheres of work—not only from the carbonizing industries. At most of our universities fuel problems of one description or another are being investigated, and there is the work of the Fuel Research Board and other bodies and individuals. The representation of our industry in all this must be the most competent and efficient that we can have. The President rejoices over all this evidence of scientific, technical, and public interest in carbonizing methods and coal treatment; and there was much truth in the crisp announcement: "Gentlemen, the pendulum has swung." It has. Even the stock markets have lately shown unusual interest in carbonizing questions; and there are to-day signs that the glamour of electricity has declined in favour of the production of oils, motor spirits, and smokeless fuels. These are matters in which a lively interest is being developed in some respects through exaggerated claims, but in others because people see in them grounds for consideration from the points of view of national independence and social improvement. The main objective, however, of the technical work of institutions and scientific centres is to ascertain how far there can be developments, with general economic results, in the co-ordination of the utilization of fuel irrespective of description. Beyond, as Mr. Thomas Hardie indicated in his recent address to the Western Junior Association (from which the President makes quotation), there are possible developments within the gas industry which should assist to the more economical utilization of its manufacturing plant at those times when part of it would otherwise be idle.

Work for the expansion of business can, of course, be prosecuted by any undertaking whatever its size; but such productive developments as those to which we have just called attention can only be undertaken by the large gas undertakings. The President spoke of the necessity for more and more research, and urged that larger funds should be placed at the disposal of the Institution for the purpose. He also said there could be no question that co-operation, amalgamation, and joint working between large and small undertakings must bring in their train benefits to the consumers by reduced capital expenditure, lower costs per therm, and the advantages of concentrated and experienced staffs and organization. Strange as it may at first sight seem, it is soon appreciated that all these movements which bring about the establishment of larger concerns for manufacturing purposes have a bearing upon technical development, research, capacity for providing funds, and so forth; and therefore in amalgamation and

the creation in our industry of more imposing undertakings with greater influence, there is one method of bringing about development of untold value. In his recent address to the Chemical Conference, Sir Alfred Mond (whom we heartily congratulate upon his accession to the peerage) spoke of the potentiality of large enterprise in all work for business development and negotiation. He has already found this in Imperial Chemical Industries, which has now a world-wide influence.

Everything is shaping for advance by these means in the gas industry. It may be that it is being done slowly, but it is being done surely. When there is conviction that large potentialities exist such as we have in our industry, then the best brains we can produce are required to bring them to material account. The Institution are looking after this. They are expecting the dignity of a Royal Charter; and they have revised their rules so that qualification for membership of the organization will be largely governed by technical knowledge and entrance by examination. They want to consolidate the technical ability of the whole industry, and to bring its influence to bear upon the work of the industry. They are also providing for the future through the Education Scheme, and insistence on higher attainments than obtained under the haphazard training methods of the past. It is, as the President urges, important that the industry should attract to its ranks men of the best calibre. But the gas industry has to learn the lesson that it will not get the best brains unless it is willing to pay for them. It has got to go forward in this respect or go under. Every big industrialist knows this, and gladly pays; it is the little industrialist whose mind cannot soar higher than a shade beyond the wages of a labourer for the remuneration of talent, who is the obstructionist. The President says truly that it is disturbing to note the low salaries that at times are offered in the gas industry for various appointments. That must cease. If we are thinking of great things for our industry in future, we must broaden our ideas, and act in a manner which will show that we have no intention of leaving a stone unturned to realize our ambitions and remarkable opportunities. These are the lines to which our thoughts are chiefly directed after reading the sapient address of the President. They are the lines of progress.

REPORTS AND PAPERS.

A few impressions on the reports and papers will be given in a subsequent number.

The Rating Bill.

IN view of the fact that the Rating and Valuation (Apportionment) Bill is now before a Committee of the Whole House of Commons, special point is given to the remarks made by Mr. Madden in the course of his Presidential Address on the subject of the exclusion of the gas industry from participation in the rate relief which it is proposed to give to all productive industries.

The Bill in its present form definitely excludes all gas supply undertakings; but it is earnestly to be hoped that, in common fairness to the industry, the House will accept an amendment which will enable at least partial relief to be obtained. In common with all others interested in the gas industry, we have from the first felt that its claim to rank equally with other industries is entirely reasonable; in our opinion the claim for a partial measure of relief is unanswerable. It is based on the fact that, in contradistinction to other public supply industries, gas undertakings produce coke, tar, pitch, sulphate of ammonia, and many other chemicals, and that in the disposal of these products they are faced with the keenest competition from other fuel and chemical industries. Nor is this competition limited to the home market. Large quantities of the products mentioned are exported, and in each case they have to meet the wider competition encountered in the markets of the world.

Is it right that a great British industry should be definitely handicapped in its competition? Is it right that such a handicap—causing, as it must, diminution in the revenue from residuals—should be allowed to affect the interests of the millions of gas consumers who keep an anxious eye upon the price of gas? We are confident that the representations which have been, and are being, made will prevent a grave injustice.

Spherical Holders.

Developments in gasholder construction are forming the subject of much discussion at present, and the importance of the general question was emphasized at the Cardiff Meeting of the Institution, not only by Mr. W. Doig Gibb, the Chairman of the Gasholder Construction and Deterioration Committee, but by several who took part in the discussions on the papers on distribution problems presented by Mr. Stephen Lacey and Mr. Harold C. Smith. Among other things, the economy of employing district holders to augment the pressure in the outlying mains at periods of peak load was mentioned; and the essence of the discussion on this matter is that, to cope efficiently with growing demand, provision of these district holders is in many cases not merely desirable, but necessary. In view of the great interest which is being displayed in the problem, our readers will be interested to learn that a British firm—the Whessoe Foundry and Engineering Company, Ltd.—are embarking on the manufacture and erection of spherical gasholders suitable for working at pressures between 10 lbs. and 50 lbs. per sq. in. The latter pressure, it is suggested, opens up a large field for the progressive engineer to explore.

Virtues of Pressure Spheres.

The spherical gasholder is not new to readers of the "JOURNAL," for illustrated descriptions of the "Hortonsphere" in its various phases of development and application have from time to time appeared in our columns. In November last Mr. R. B. Hodgson, the Managing Director of the Whessoe Foundry and Engineering Company, Ltd., made reference to it in his address as Chairman of the Council of the Society of British Gas Industries ("JOURNAL," Vol. 180, p. 551); and during the same month (p. 604) a translation by Mr. W. S. Gray of an article in "La Génie Civil" gave the mathematics of the cylindrical container. Among the chief advantages of the spherical holder are the low first cost—due to the facts that no tank is necessary and that the foundations are very small—the low maintenance charges, and its extraordinary flexibility, for the cost for any given capacity is theoretically independent of the maximum pressure for which it is designed. Moreover, besides having a pleasing appearance, it minimizes the usual difficulties of selecting a suitable site. There can be no question that the merits of this type of holder, which has been largely adopted in the United States, must claim the attention of gas engineers generally.

Sheffield Again.

We heartily congratulate Mr. Ralph Halkett, the General Manager and Secretary of the Sheffield Gas Company, on once again reducing the price of gas in his area of supply. To quote a local paper, this reduction "is clear evidence of the anxiety of the Gas Company to do what it can to bring down costs and so to aid in trade revival." It will be seen from the new schedule of prices, which is published in later columns, that the gas consumed in excess of 375,000 therms per annum on the same premises will be charged for at 1s. per 1000 c.ft. Even the ordinary consumer in Sheffield will now obtain his gas for 6¾d. per therm, which is equivalent to 2s. 9d. per 1000 c.ft.

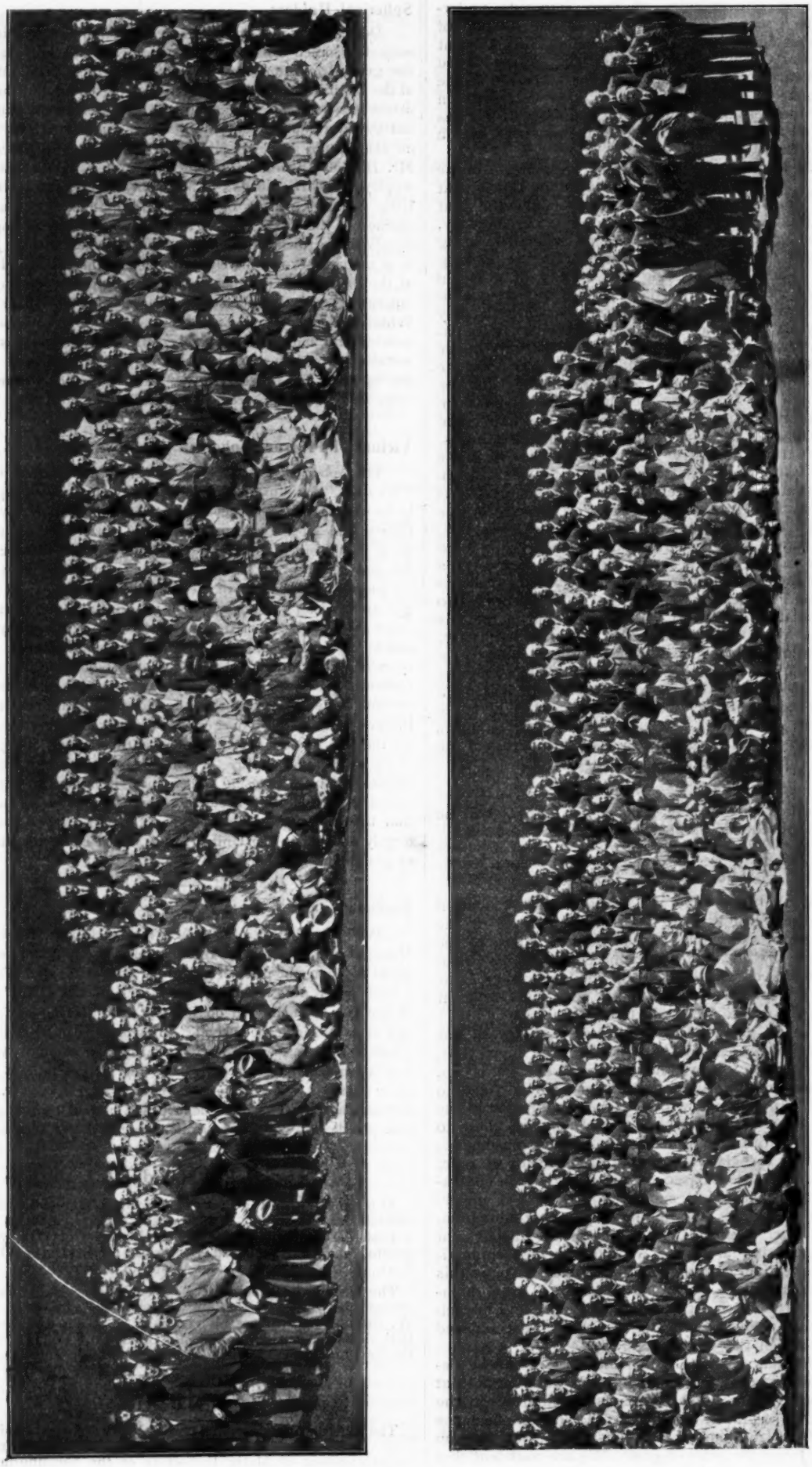
PERSONAL.

At the meeting of the Provincial Grand Lodge of Freemasons (Middlesex) on Monday of last week, W.Bro. CHARLES CLARE, a Past-Master of the Evening Star Lodge, No. 1719, was appointed a Grand Standard Bearer, by H.R.H. the Duke f York, R.W. Provincial Grand Master of the Province.

The Bradford Corporation Gas Committee have placed on record appreciation of the long and valuable services of Mr. A. W. BUTTERFIELD (Stores Manager), Mr. ALFRED FLATHER (Statistical and Costs Clerk), and Mr. H. LAWTON (Works Superintendent) on their retirement on superannuation allowance.

OBITUARY.

The funeral took place on Tuesday, at Brandwood End Cemetery, Birmingham, of Mr. ERNEST HARRY WARD, aged 45, Superintendent of Meter Inspectors of the Birmingham Gas Department. His death, which occurred on the previous Friday, was due to pneumonia.



A PANORAMIC PHOTOGRAPH TAKEN OUTSIDE THE CORY HALL, CARDIFF, ON JUNE 13.

THE INSTITUTION OF GAS ENGINEERS.

PROCEEDINGS AT THE ANNUAL GENERAL MEETING

HELD IN

THE CORY HALL, CARDIFF.

JUNE 12, 13, and 14, 1928.

President: HENRY DACRE MADDEN, Esq., M.Inst.C.E.

A REVIEW OF THE PROCEEDINGS.

"Croesaw." This was the word which, displayed at the back of the platform, met the eyes of the members of the Institution as they flocked into the Cory Hall, Cardiff, for the opening session on the Tuesday morning. Some, alas, were in need of an interpretation—those who use a different word to imply the same thing. The latter is one the world over, though in degree it may differ. In Cardiff, the members were to learn, it is practised in its fullest sense. "Croesaw" means "Welcome." Great in other respects, Cardiff is also great in heart; and the hospitality extended to the members made a deep impression upon all. It was, indeed, a week without regrets. The unanimous feeling was that the Institution had been extremely happy both in their President and in the fact that his home is in Cardiff. It was, of course, a personal triumph for Mr. Madden and for those who formed the Reception Committee, who have had the greatest possible reward in the obvious satisfaction of the members with the arrangements that were made. As the reports on succeeding pages show, there is the best of reasons for the belief expressed by Sir David Milne-Watson (when proposing, at the dinner given by the Cardiff Gas Light and Coke Company to the President and Council, the toast of "The Institution of Gas Engineers") that the meeting of 1928 will mark a stage in the progress of the gas industry. In short, to adopt the motto on the City of Cardiff coat of arms—"The Red Dragon gives the Lead."

H. D. MADDEN, M.Inst.C.E., M.I.Mech.E.

Welcome to Cardiff.

On behalf of the citizens of Cardiff, which hopes one day to be the recognized capital of Wales, the Lord Mayor, the Right Hon. Alderman A. J. Howell, J.P., welcomed the Institution, saying how well he realized that the gas industry in this and other countries is rendering service in ways both great and small. His welcome was followed by one by Mr. Lawrence C. Williams, the Chairman of the Cardiff Gas Light Company, on behalf of the Company. The President, in his reply, said that the Institution had made the Lord Mayor a member—an announcement which gave rise to the liveliest satisfaction.

Reading of messages from sister organizations was followed by a cordial welcome to the delegates from abroad, to which Mr. John Irminger, of Bergen, replied on behalf of the foreign delegates, and Mr. H. W. T. Pilbeam, of Santos, and Mr. Andrew Wilson, of Sydney, on behalf of the British overseas delegates. Then Mr. Will Thorne, M.P., who is Vice-Chairman of the National Joint Industrial Council for the Gas Industry, expressed his pleasure at being invited to attend the meeting, and took the opportunity of paying tribute to the broad-mindedness and ability of Sir David Milne-Watson, who has been Chairman of the Council since its inception in 1919—an organization which, said Mr. Thorne, "is one of the most intelligent bodies there is in the country."

Membership of the Worshipful Company of Plumbers.

The Secretary, Mr. Walter T. Dunn, next read a telegram from Mr. George Ratcliffe, the Lord Mayor of Leeds, wishing the meeting all success, and, among other letters of regret, a communication from Dr. Charles Carpenter, the President of the South Metropolitan Gas Company, expressing his regret at his inability, as the result of ill-health, to be present at the "concluding function of an epoch-making Presidency." Mr. Dunn then intimated that the Worshipful Company of Plumbers had offered members of the Institution membership of that Company.

Award of Honours.

The next item in the proceedings was to present the H. E. Jones "London" Gold Medal to Mr. Thomas Carmichael, of Portsmouth, for the paper which he read on "Modern Carbonizing Economics as Exemplified at the Works of the Portsmouth Gas Company"—which, as the President observed, "was one of the most valuable contributions that we have had of recent years." We heartily congratulate Mr. Carmichael on an award which was unanimous, and once again on a paper which has been, and still is, of great value to the gas industry.

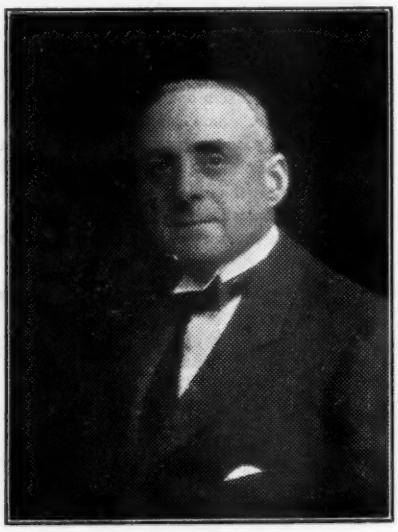
Then followed the presentation of the Institution Diploma to Messrs. John Grayston, of Hinckley; Roy Summerson, of Luton; Frank C. Sylvester, of West Bromwich; James L. Hyslop, of Belfast; W. I. Ineson, of Bradford; Harold B. Kendrick, of Carlisle; and E. H. Winch, of Cambridge. As the industry is aware, the Diploma Examination is no light one; Diplomas have to be won by sheer merit. We heartily endorse the President's hope that in years to come the names of the recipients will "come high up in the records of the Institution."

The Presidential Address.

Following the election, as temporary honorary members of the Institution, of the Presidents of the National Gas Associations of Australia, Belgium, Canada, Czecho-Slovakia, Denmark, France, Germany, Italy, Norway, Sweden, Switzerland, and the United States of America, the President proceeded to deliver his address, which is the subject of editorial comment in our columns to-day, and which was—to use the phrase employed by Mr. A. E. Broadberry in proposing a vote of thanks to Mr. Madden—very inspiring. Mr. Thomas Glover, of Norwich, who seconded the vote, also observed that the address would be a source of inspiration to members of the Institution during the coming year.

Swansea's Morriston Works.

Formal acceptance of the annual report and accounts of the Institution brought us to the first technical contribution, by Mr. W. H. Johns. This paper, which describes the first complete unit of the new Morriston Gas-Works designed and erected by the author, is supplementary to his Presidential Address before the Wales and Monmouthshire District Institution of Gas Engineers and Managers in 1924, which was published in the "JOURNAL" for Nov. 19 of that year. The unit which has now been completed consists of coal gas plant and carburetted water gas plant having capacities of 3 and 2¼ million c.ft. per day respectively, together with a reserve 1¼ million carburetted water gas set. Mr. Johns gives his reasons for adopting horizontals. In the first place, the new site is extensive, and the question of maximum gas-making capacity per unit area—a point on which verticals score so heavily—was not a vital consideration; secondly, the plant had to be capable of maximum efficiency when carbonizing lower-grade coals; thirdly, coke resulting from a static charge is more suitable for local requirements than that produced from a dynamic charge. Moreover, at Swansea it is rarely possible to dispose of the current production of coke, and thus it is essential to adjust the supply to the effective demand, via carburetted water gas. Some of the retorts were constructed in segmental silica blocks; but Mr. Johns' experience of these was by no means happy, and ultimately they were replaced by moulded fireclay retorts.



W. H. JOHNS, M.I Mech.E.

In his Presidential Address, Mr. Johns described the coal gas unit. In this paper, therefore, he deals in detail with the carburetted water gas plant. The reserve unit, by Humphreys & Glasgow, was formerly at the Company's Oystermouth Road Works, and is hand-clinkered. The new plant, also by Humphreys & Glasgow, is complete with self-clinkering generator, mechanical coke charger, reserve make apparatus, and annular boiler.

Coal and Coke Handling.

The coal stocking system at Morriston comprises a locomotive crane, provided with a grab, a ferro-concrete grabbing pit equipped with hydraulic wagon tipplers, and an open yard heap. On 12-hour charging, the maximum requirements of the retort house are 240 tons, which can be provided by the crane in six hours at a labour cost of 0·75d. per ton of coal. The utility of the system was most pronounced during the coal strike of 1926, when single consignments of foreign coal amounted to 3000 tons, the delivery of which was concentrated within a few days. As the author explains, no additional labour was necessary to handle such concentrated deliveries, and traffic in every case was promptly released. A locomotive crane, provided with grabs and skips, is also employed for coke transport.

Quenching of the coke is effected on a ferro-concrete bench, sloping at 40° to the horizontal, constructed the whole length of the retort house; the various bays being

lined with cast-iron plates 2 in. thick. Of course, dry cooling plant was considered; and Mr. Johns explains why it was not adopted. The chief stumbling-block was that the capital cost was not justified by the size of the first unit of works. The Morriston Works, however, are laid out for an ultimate capacity of 12 million c.ft. of coal gas and 6 million c.ft. of water gas per diem; and he observes that, when the plant is extended, a dry cooling unit with waste-heat boiler may be a good proposition.

Unveiling of the Welsh National War Memorial.

Following Mr. Johns' paper members and their ladies proceeded to Cathays Park to witness the impressive unveiling ceremony of the Welsh National War Memorial by H.R.H. The Prince of Wales, who is an Honorary Life Member of the Institution.

Discussion on Mr. Johns' Paper.

This took place when the meeting was resumed on Tuesday afternoon, and centred largely on the question of silica retorts. Lieut.-Col. W. M. Carr, of Stretford, explained how he had overcome the difficulty of joints opening in silica segmental retorts at his own works, by inserting shield tiles. Mr. F. P. Tarratt, of Newcastle, gave his experiences of silica retorts, which are operating with great success at his works, and mentioned his preference for a retort of 24 in. by 16 in. section, which he considers has far greater strength than the 24 in. by 18 in., and equal carbonizing capacity. In his reply, Mr. Johns observed that his unfortunate experience with silica at the Morriston Works has not damped his ardour to experiment again with another type of silica material, for he fully appreciates that the employment of silica means greater throughput and lower carbonizing costs.

Mr. R. E. Gibson's remarks on the automatically controlled water gas units at the Garston Works of the Liverpool Gas Company are of great interest. It is generally understood throughout the gas industry to-day that water gas production is not so economical as coal gas manufacture. This, however, is contrary to Mr. Gibson's findings; for in his new Humphreys & Glasgow plant he can make a therm of water gas more cheaply than a therm of coal gas.

Resignation of Prof. Smithells and Mr. Charles Wood.

In an introduction to the Nineteenth Report of the Research Sub-Committee of the Gas Investigation Committee, the presentation of which followed the discussion on Mr. Johns' paper, Prof. J. W. Cobb refers to the resignation of Prof. Arthur Smithells from the office of Chairman of the Research Sub-Committee—an office which he has so ably filled ever since the official co-operation of the Institution and the University of Leeds. The services he has rendered to the gas industry as a scientist and administrator are invaluable. It was he who demonstrated that, if the industry wished to prosper in a scientific age, it must regard science as its most important ally; and the industry owes a deep debt of gratitude to his enthusiasm, broad vision, and delightful personality. In Mr. Thomas Hardie, the Chief Engineer of the Gas Light and Coke Company, he will have a worthy successor. Another change in the constitution of the Joint Committee is that Mr. C. F. Botley has taken the place of Mr. Charles Wood, who, after many years of effective service on the Committee, has retired from professional work on account of ill-health.

Combustion Products from Gas Appliances.

The report, which was presented by Mr. J. W. Wood, is an account of further work on the combustion products from gas appliances, which was started in 1925 by an investigation of the iodine pentoxide method for the determination of carbon monoxide (Fifteenth Report), and continued in 1926 by an examination of the combustion products from gas fires (Seventeenth Report). During the past year Mr. Wood and Mr. C. B. Howarth have devoted their attention to free-burning flames, as distinct from those which come in contact with solids. A marked difference has been found in the carbon-monoxide production of free-burning and partially obstructed flames; and consequently generalizations based on results obtained with appliances using free-burning flames must not be made respecting gas appliances as a whole.

It is clearly shown that the quantities of carbon monoxide generated by free-burning flames in typical gas appliances under normal conditions of use are minute, and that the luminous flame is as good as the bunsen flame in this respect. One of the interesting findings is that bunsen burners show a regular increase in carbon-monoxide production as the primary aeration is diminished.

The appliances tested included a flueless heater of the condensing type, a storage water heater, a "closed" geyser, a calorimeter, and a top-flue oven fitted with two burners. Work on a bottom-flue oven is in progress. As Prof. Cobb suggested, in introducing the report, the results are of great practical value to the industry. With regard to the flueless heater, the carbon-monoxide production at the rated gas consumption (6 to 8 c.ft. per hour) was extremely low—only one part in 100,000 of gas burned. In other words, assuming the heater to be in use twelve hours a day, the carbon monoxide produced during the whole of that period amounts to less than 0·001 c.ft. Even when the gas consumption was raised to 10 c.ft. an hour, the carbon-monoxide production rose only slightly.

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Geyser Ventilation.

From the results obtained with the geyser, it appears that, if a steady draught is maintained through the appliance, the carbon-monoxide production is satisfactorily low if the carbon-dioxide concentration in the flue gases does not exceed 8·3 p.ct. Above this figure, the carbon-monoxide production rises rapidly. The aim, then, should be to ensure adequate draught through the geyser; and in this connection a fact which should be more widely known is emphasized in the report: "The draught through the combustion chamber is largely dependent on the length of flue pipe used—not the total length of flue pipe, but the unbroken length below the baffler. It is therefore advisable to place the baffler as high above the geyser as

the ceiling will permit, and to limit the gas rate to the appliance accordingly."

Lighting-Back.

In the gas oven tests, it was found that the carbon-monoxide production diminished regularly as the gas rate was increased; and some very low values were obtained. One of the incidental findings concerns lighting-back, and dispels an illusion. It sometimes happens that the gas becomes ignited at the oven burner nipple, and with the primary air undergoes incomplete combustion inside the burner body. The mixture issuing from the burner in this case may contain sufficient combustibles to burn, but the flame has a "curious lambent yellow appearance." This state of affairs is commonly regarded as dangerous. In one test the cooker was operated under such conditions, "but there was no objectionable odour from the flue outlet, and the carbon-monoxide production, though slightly higher than for normal combustion, was surprisingly small."

While making the carbon-monoxide determinations, information was collected respecting the thermal efficiency of some of the apparatus tested. A thermal balance is given for the gas oven, and it was found that the efficiencies of the storage water heater and the "closed" geyser were 75 to 80 p.ct. and 78 to 83 p.ct. respectively.

Gas-Fire Radiants and Good Flames.

In the course of a short discussion on the report, Dr. E. W. Smith suggested that the gas fire radiant might be improved to ensure quicker and more complete combustion. At present, the amount of air which passes through the sides of the radiant, which fits the flame too closely, is insufficient. There may be unburnt gases at the top of the radiant, and that the blanket of products of combustion may render it impossible to burn the small trace of carbon monoxide completely. Dr. W. B. Davidson rose to do honour to low-grade gas. The best flames, he thinks, are not those produced by high-grade gas at ordinary pressure, but those produced by low-grade gas at a higher pressure. The latter flames are of the "solid uniform type."

An Intensive Study of Carbonization.

Dr. A. Parker then presented the Twentieth Report of the Research Sub-Committee of the Gas Investigation Committee—the results contained in which "represent perhaps the most complete survey ever made of the effects of carbonization at different temperatures on the quantity and quality of the gas, coke, tar, and liquor." The words quoted are employed by Prof. Cobb in an introduction to the report, which emphasizes once again that much greater outputs are likely to be obtained by a process of incomplete carbonization using a high-temperature head, than by a system of low-temperature carbonization. The work described in the report constitutes the third stage of an investigation of the influence of various factors on the yields and physical and chemical properties of the products obtained when coal is carbonized. The first factor studied (Sixteenth Report) was that of variation in the size of coal; in 1926-27 (Eighteenth Report) the examination was continued with the object of obtaining information on the influence of the temperature of the retort and the addition of coke breeze, calcium carbonate, iron oxide, and sodium carbonate to the coal. The present report completes the experiments planned for the particular Nottinghamshire coal.

Influence of Size of Coal.

The sizes of coal ranged from 1¼ in. to ¾ in. down to 8 to 30 mesh, and the temperatures from 980° C. to 344° C. Size-grading, it was found, had little effect on the yields of products when the carbonizing temperature was below 820° C. At the higher temperatures (980° C. and 915° C.), however, the thermal values of the gas made were lower with the largest grade of coal, and the yields of tar greater. In the earlier stages of carbonization, gas was evolved most rapidly from the largest grade of coal, and the rate of gas production decreased with diminution in the size of coal. As Dr. A. Parker (who was assisted in the work by Mr. H. Kerr and Dr. C. B. Marson) observes, measurements of rates of gas production are of value when considering at what stage processes of carbonization cease to be economical; and he points to the fact that economies might result from the screening of coal; the screened coal and the fines being carbonized separately. That considerable economies do result was clearly demonstrated by Mr. Thomas Carmichael in his paper on "Modern Carbonizing Economics" before the Institution last year. By eliminating dust and fines from the unscreened coal as received by the Portsmouth Gas Company, and carbonizing the large coal in verticals, the thermal yield per ton has been increased 10 p.ct., and the output of the plant by no less than 20 p.ct. The fines resulting from the screening are carbonized in the horizontal plant.

Effects of Blending and Admixture.

From the results of experiments on mixtures of coal and coke breeze, the conclusion is drawn that the disadvantages more than counterbalance the advantages of blending coke with the particular coal of moderate coking properties examined. The temperature of the retort exerts a great influence not only on the thermal yield of gas, but also on the rate of gas production. With 8 to 30 mesh coal, the total heat values of the gas per ton of coal fell from 75·8 therms at 979° C. to 44·8 therms at 630° C., and 19·2 therms at 435° C.; and at the end of one hour, the volumes of gas produced at 630° C. and 819° C. were only 9 p.ct. and 44 p.ct. respectively of the volume made in the same time at 979° C.

The results of carbonizing mixtures of coal and calcium carbonate, iron oxide, or sodium carbonate (98 parts of coal with 2 parts of the corresponding oxides of these substances) are interesting. With sodium carbonate, the therms of gas per ton of coal increased at all temperatures of carbonization above 600° C.; and the rates of gas production at all stages of carbonization with the retort at 915° C. and 815° C. were greater. The other compounds had similar, but smaller, effects, and the quantities of sulphuretted hydrogen in the gas were reduced by all three; iron oxide being most effective. The amounts of ammonia produced were greater with the mixtures; a 35 p.ct. increase being obtained with calcium carbonate at 915° C.

The cokes produced from blends of coal and coke were more friable than the products from coal alone. Below 700° C. calcium carbonate and sodium carbonate reduced the strengths of the cokes, and iron oxide rendered the cokes more friable at all temperatures below 900° C. At the end of the report, a brief account is given of the work in progress with the object of determining the relative ignition temperatures and reactivities towards steam and carbon dioxide of the cokes made during the investigation. In this connection it has already been shown that decrease in temperature of carbonization increases reactivities towards steam and carbon dioxide, and that the cokes obtained at 915° C. by the carbonization of mixtures of coal with the three inorganic substances were more reactive and more easily ignited than coke from coal without addition.

Lack of Time Limits Discussion.

Brief discussion of the Twentieth Report brought Tuesday's proceedings to a close. It was brief not because of any lack of interest, but through lack of time. All the speakers consider the work of extreme value. As Mr. T. F. E. Rhead remarked, investigations at Leeds are knocking the "ifs" and "buts" out of carbonizing arguments. Mr. Rhead expressed his interest in the fact that, with mixtures containing 10 and 20 p.ct. of coke, Dr. Parker can find no appreciable increase or decrease in thermal yield or tar yield, for Mr. Rhead suspects a reduced thermal yield as a result of carbonizing briquetted mixtures of cokes and coals in vertical retorts. Mr. Harold Hollings, of the Gas Light and Coke Company, admires Dr. Parker's restraint, and hopes he will conduct further experiments with a more strongly coking coal, "in order that wrong conclusions shall not be drawn from the work described in the report." Mr. Harold E. Copp, of Hull, who is a member of the Committee, suggested

that any idea that the practical results obtained are not commensurate with the volume of work done is misplaced. The fact that the specific gravity of the tar decreases rapidly with reduction in carbonizing temperature, he said, ought to have an important bearing on what we hear so much about nowadays—low-temperature carbonization. Tar of low specific gravity is a nuisance; it is difficult both to handle and to distil.

The New Office-Bearers.

On Wednesday morning, the business of the annual general meeting of the subscribers to the Benevolent Fund having been satisfactorily discharged, the result of the ballot was announced; and loud applause greeted the intimation of Mr. John Terrace's coming Presidency. Mr. C. S. Shapley is Senior Vice-President, Mr. Harold E. Copp, Junior Vice-President, Mr. W. E. Price, Hon. Secretary; and Messrs. H. E. Bloor, F. P. Tarratt, W. W. Townsend, and J. Wesley Whimster take seats in the Council.

Gasholder Committee's Interim Report.

The Chairman of the Gasholder Construction and Deterioration Committee, Mr. W. Doig Gibb, then presented an interim report of this Committee; and his remarks will be found in our "General Report" on later pages. The President, moving the adoption of the report, mentioned that the work required tactful handling, and said that the Committee welcome suggestions which any members of the Institution may care to offer.

Economics of High-Pressure Distribution.

Then came Mr. Stephen Lacey's paper on "The Economic Aspects of High-Pressure Gas Distribution"—an excellent corollary to his sensational paper on "The Flow of Gas in Pipes" before the Institution when they

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met at Belfast in 1923. Though the former has less of the appearance of one of the compositions of Brahms, Mr. B. R. Parkinson's remarks on the 1923 contribution—that it was a monumental work compressed into a small space, but still making remarkably clear reading—apply aptly to the paper now under review. There can be no question that Mr. Lacey knows the meaning of the word clarity; and it was peculiarly fitting, too, that his contribution should precede Mr. H. C. Smith's account of recent extensions in the distribution system at Tottenham.

The main object of the paper is to answer the question: Given the length of main, the maximum rate of gas delivery, the variations from that rate, and the terminal pressure required in the main, what is the economic combination of the diameter of main and the initial pressure? Confusion often arises from the use of the terms "high pressure" and "low pressure;" and throughout his paper the author regards "high pressure" as any pressure greater than the maximum allowable in mains from which consumers are ordinarily supplied without the use of service governors—this limit being 8 in.—and his calculation of rates of flow are based on his modification of Unwin's high-pressure formula.

Three Examples.

What Mr. Lacey does is to calculate the maximum rate of gas delivery for a number of mains of different diameters, and to determine the annual main costs and pumping costs for each combination of size of main and initial pressure; the most favourable combination being that for which the sum of main and pumping costs is the minimum. He tabulates three examples. The first is of a 10-mile main required to deliver 50,000 c.ft. an hour; and it is shown that the most economical combination of diameter of main and initial pressure, assuming continuous pumping at the maximum rate of gas delivery, is 10 in. and 3·7 lbs. per sq. in., and also that, as the duration of the pumping per annum decreases, the economical initial pressure increases and the corresponding diameter of main decreases. Comparison of the results of the second example (10 miles of main; 1 million c.ft. an hour) with those of the first demonstrates that, for a particular length of main, the economic pressure decreases as the rate of gas delivery increases—a point which is not at all obvious. Comparison of the results of the third example (100 miles of main; 1 million c.ft. an hour) with those of the second indicates that, for a particular rate of gas delivery, an increase in the length of main results in a decrease in the economic diameter of main, and an increase in the initial pressure. With regard to the aggregate time of pumping, as this decreases, so the economical pressure increases.

The general conclusions reached, states the author, provide a rational justification, on the one hand for the employment of relatively low initial pressures (under 10 lbs. per sq. in.) for the feeder mains of distributing systems supplying large towns and their growing suburbs, and on the other hand for the employment of relatively high initial pressures in mains supplying a number of small towns and villages at a considerable distance from one another. In the three examples already mentioned the total main and pumping costs per 1000 c.ft. would be only slightly increased if a diameter of main were selected greater than that corresponding with the minimum cost; and Mr. Lacey recommends the choice of the larger diameter where it is impossible to forecast accurately the load the main will have to meet.

More Useful Maxims.

When a high-pressure main is needed to reinforce the supply to a partially developed district adequately supplied except at peak loads, then the diameter of main and the initial pressure ought to be determined on the basis that the duration of pumping will be in excess of immediate requirements; and in no case should a duration of less than 1000 hours per annum be taken.

From the foregoing it will have been gathered that Mr. Lacey's paper is of the utmost practical importance. It will certainly be a constant source of reference to "extensionists." Of great practical value, for example, are his comments on the economies of a suitably located holder for use in conjunction with the system of mains directly supplying the consumers in the area where the additional gas is required. He observes that it may be found that the annual charges in respect of the erection of a holder will be more than compensated for by the saving in the annual main and pumping costs, consequent on the reduction in the maximum rate of delivery.

Work in Sydney and Rio de Janeiro.

The discussion which followed Mr. Lacey's paper must have been highly gratifying—if at times a trifle em-

barrassing—to the author. All who took part were loud in their praises, and observed that the contribution would stand as a source of constant reference. Mr. Andrew Wilson said how he wished the paper had been available when he was carrying out distribution extensions in Sydney. His area of supply is 250 square miles, and he has about 1850 miles of main, 300 miles of which are high-pressure. He gave an account of how he had tackled the problem of meeting the increasing demands for gas. He has now reached the maximum economical load on his mains, and his next step will be to instal district holders of capacities varying from 2½ to 9 million c.ft. His remarks on fans were extremely interesting. He mentioned that it is only at certain rated outputs that they give the desired pressure; and that often it is a case of excess volume but insufficient pressure. For this reason he has gone in for positive machines of the National-Michell crankless gas engine type coupled to Waller crankless compressors—an illustrated description of which was published in the "JOURNAL" last August. Mr. Wilson is highly satisfied with the working of these machines, which possess remarkable flexibility.

Senor Oliveira explained briefly what they were doing in Rio de Janeiro. The problems there are unique, as will be gathered when we record the fact, mentioned by the President, that in the centre of the residential district is a mountain 3000 ft. high.

The Value of District Holders.

Mr. Madden stressed the advisability of erecting district holders to augment the pressure at peak loads; these holders being filled at periods of minimum demand. The same point was referred to by Mr. F. H. Robinson—who stated that in his case the diameter of the mains in a certain area would have to be increased 2¼ times if no holder was available—and by Mr. C. S. Shapley. The latter observed that, in an area recently taken over by the Leeds Corporation, the peak load is on Mondays—the wash-day. Mr. Robinson does not regard large mains and low pressures as being applicable generally; and he explained his high-pressure system at Harrogate, where he has a high-pressure belt main round the town, and from this not only supplies outlying villages, but augments any deficiencies in the central districts. He considers that Mr. Lacey's figures for the cost of mainlaying certainly do not err on the low side. On the question of the size of main, the President mentioned an instance in Cardiff where the size was governed by the fact that in one place, on a bridge, there was only ⅜ in. clearance for the sockets of the main, which, of course, limited the possible diameter.

Ensuring Good Service at Tottenham.

Of what does good service consist? The answer is given by Mr. H. C. Smith in the early part of his paper on the "Extensions and Modifications in the Tottenham Distribution." A good sales organization and an efficient maintenance scheme cannot result in customer-satisfaction unless the gas is of constant pressure and uniform calorific value, and is free from any constituent likely to cause blockages. Any system for the inspection of appliances, to ensure that they are functioning efficiently, is costly; and the cost is in inverse ratio to the general efficiency of a gas undertaking. The chief cause of complaint is without question lack of pressure; and the theme of Mr. Smith's contribution is an explanation of how he has endeavoured to eliminate this cause in his area of supply. When it is stated that the output of the Tottenham Company has doubled every eight to ten years from 1899 to 1917, it will be appreciated that the task has been no easy one.

Incidence of the Cooking and Heating Loads.

For many years the pressure thrown by the holders was ample for the whole district, but the gas cooker and the development of heating peak loads soon put a different complexion on the matter. Boosters were adopted, and this system worked well so long as the capacity of the high-pressure (up to 50 in. W.G.) mains was sufficient to carry all the gas required to the points of discharge into the low-pressure mains at such a pressure as not to be excessive for the appliances of consumers whose supplies were taken off nearest the point of discharge, and so long as the low-pressure system was adequate to distribute gas to the remaining consumers at a satisfactory pressure. However, these conditions obtained only temporarily. In the case of Tottenham the consumption of gas increased so rapidly as to outgrow the distribution system; and the author mentions that the point was reached when a pressure increase of 4 in. to 5 in. was required at the works to give a wave sufficient to cause the sudden increase of half-an-inch required for the Broadberry lamp lighting and extinguishing system, in the parts of the district farthest from the works.

How the Situation was Tackled.

Conditions had to be remedied; and it was decided to a lay a 48-in. main from the Willoughby Lane Works to a point on an arterial road which, running through the district from south to north, divides it approximately into two halves. The length of this main (uncoated cast-iron spigot and socket piping was used) is 9820 ft. Having dealt with the matter of wayleaves, the author describes in detail how this main was laid; and the story is one of great interest. Each joint was tested separately under an air pressure of 30 lbs., and an air test at the same pressure was applied to approximately each half-mile of main as laid. Then came the final test; and only one serious leak was discovered. This was a split socket, and it shows the importance of testing mains before they are gassed. Mains of 30 in. and 24 in. diameter were laid along the arterial road.

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The author, in the next section of his paper, explains how the system was modified for levelling-up pressures. The standard aimed at was to provide every consumer with an even pressure throughout the 24 hours, this pressure to vary between 6 in. and 4 in. in the mains for the low-pressure system. High pressure was extended farther into the district by converting some of the larger low-pressure mains, and district governors of the Peebles air-pressure loading mercurial type were installed at the starting point of the low-pressure system. Widlake recording apparatus was installed as a further precaution; and Mr. Smith expresses his admiration of the excellence of their design and construction.

The Result—Satisfied Consumers.

The work cost £113,307, and the interest on this, at 6½ p.ct., is £7365 per annum, to which is added a payment of £177 to the G.P.O. The author concludes his

paper by saying that there are 96,889 consumers in the Tottenham district, and thus £7542 is equal to 1s. 6½d. per annum per consumer. Such a sum would not provide much inspection or maintenance for any consumer's apparatus; "but for this sum provision has been made to meet future extensions, and, in addition, existing consumers have been provided with what they have a right to expect—adequate and reasonably even pressure at any hour of the day or night."

Methods Employed in America.

Mr. Botley launched the discussion on Mr. Smith's paper by asking if the final records of pressure were taken at the same points as the preliminary survey, and if the satisfactory line of pressure is really translated to the whole of the district a governor serves; and on both these points the author was able to satisfy Mr. Botley. Mr. Ralph Halkett followed, and waxed enthusiastic over high-pressure distribution, which he has adopted with great success in Sheffield.

Then Mr. G. M. Gill spoke of the possibilities of 2-in. steel pipe, the employment of which has an important bearing in reducing capital costs for mainlaying. He observed that in the United States it is customary for undertakings to have as much as 70 or 80 p.ct. of their total main mileage in 2-in. steel pipe. The feeder mains are large, and ensure a plentiful supply of gas at each end of the small pipe. A 2-in. pipe, he said, 4000 ft. long, supplied with gas at each end, will deliver 1700 c.ft. of gas an hour with a pressure-drop of 2 in. The author gave 13½ c.ft. as the consumption per consumer during the maximum hour; and on this basis the 2-in. pipe would distribute the necessary gas to 100 consumers during the maximum hour. Mr. Gill also referred in glowing terms to the trench digging machine which is seen in the States. This impressive machine will accomplish ¼ mile a day in average soil, and is eminently suitable for use in this country.

A Perfect Gas—then Maintenance.

Staunch champions of maintenance were to be found in Mr. W. W. Townsend, of Colchester, and Mr. W. Clark Jackson, of Neath; both of whom were grieved that Mr. Smith had seemingly made light of this important problem. The author assured them, however, that it is far from his desires to deprecate the value of maintenance schemes. What troubles him is the cost. Published figures are too nebulous; and before launching a maintenance scheme, surely they ought to be able to supply a perfect gas? A satisfactory gas implies a cheaper and better maintenance system.

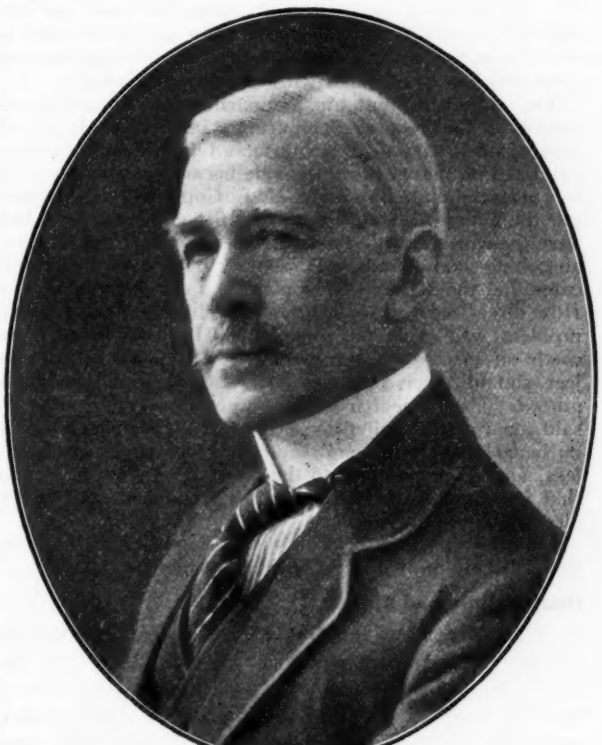
Mr. J. Wesley Whimster, of Bath, indulged in a little arithmetic, the outcome of which appeared to indicate that the amount of gas used by each consumer at Tottenham during the maximum hour is the normal hourly consumption. Mr. Smith, however, explained that 75 p.ct. of his consumers have prepayment meters, and their average annual consumption is 25,000 c.ft., which, unfortunately, did not compare favourably with that at Bath. It is an astonishing fact, he remarked, that, in spite of increased cooker sales, the Sunday cooking load has not increased proportionately; and he offered the solution, which relieved the technical strain, that hire-purchase of motor-cars had resulted in people leaving their homes on Sunday.

At the close of the discussion, Mr. Madden intimated that Dr. E. W. Smith had suggested the formation of a small standing Committee to consider distribution problems.

The Effluents Problem.

The disposal of effluents from gas-works has during the past few years become more difficult, and a solution of the problem is a matter of immediate necessity. Consequently, when the meeting was resumed on Wednesday afternoon members were interested to hear what had been accomplished during the year by the Effluents Research Committee, of which Mr. C. F. Botley is Chairman and Dr. A. C. Monkhouse Research Chemist.

In a summary to the Second Report of the Committee, Dr. Parker points out that the usual gas-works practice of storing tar and liquor in the same well increases the effluent difficulty, for the ammoniacal liquor absorbs higher tar acids. Tar and liquor should be separated as soon as possible, and stored separately. The work was carried out at the Hinckley Gas-Works, and a tar extractor designed by Messrs. Woodall-Duckham was installed in the hot foul gas main in the retort house, to remove the heavier tar at a temperature above the dew-point of the gas before condensation of liquor commenced. The extractor reduced the quantity of higher tar acids in the mixture of liquors condensed at different points from the equivalent of 240 parts of oxygen absorbed to 150 parts per 100,000; and still further improvement is anticipated if a larger proportion of tar can be deposited from the hot gas.



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Discussing oxidation of the liquor, Dr. Parker states that air for purification should be admitted at the inlet to the purifiers, if the quantities of thiocyanate and thiosulphate in the liquor are to be kept to the minimum; also, diminution in the temperature of the liquor in the tar and liquor well, as a result of the installation of the tar extractor, has decreased oxidation of the liquor. Another suggestion made is that the devil liquor should be treated separately by such methods as evaporation in a chimney. At Hinckley, for example, an improvement of 20 p.ct. in the oxygen absorbed value of the totai effluent would be attained in this manner.

Regarding the general disposal of effluents, large and sudden changes in the proportion of gas liquor effluent to sewage should be avoided by the installation, if necessary, of balancing tanks to allow for periods when the ammonia distillation plant is not in operation. It has been proved that, in normal circumstances, admission to the sewers of effluent in constant proportion to the sewage flow "is a technically satisfactory method of disposal."

Prof. Cobb mentions, in an introduction to the report, that a Special Committee has been constituted to consider the position of the gas industry in regard to ammonia production and disposal—an urgent question in view of the development of synthetic methods of producing sulphate.

Work which Needs Support.

Mr. Botley presented the report, and he was followed by Prof. Cobb (who held out the hope that a solution to the problem would eventually be found), Dr. Parker, and Dr. Monkhouse; the latter describing the sewage plant

at Hinckley, and giving a summary of the results of his work. The President urged that those members who, perhaps as a result of being situated near the sea, were not faced with the difficulty of getting rid of their waste liquors, should help their less fortunate comrades. Mr. S. J. Thorman, of the Gas Light and Coke Company, mentioned that during the year there had been two excellent theses on effluents submitted for the Diploma of the Institution. One of these was really splendid, but unfortunately the candidate's knowledge on the engineering side did not warrant the award of the Diploma. The name of the author of the other thesis was Mr. John Grayston, of Hinckley, who had gained the Diploma with distinction in all three classes.

Mr. Ferguson Bell, of Derby, explained that for two years they had been studying the problem at Derby, which was one of the "unfortunate" towns far from the sea; and he intimated that he would place at the disposal of the Committee all the findings of this investigation—an offer which was accepted with much appreciation.

The statement that air for purification should be admitted at the inlet to the purifiers interested Mr. P. S. Hoyte, of Plymouth. He observed that when this was practised on his works, the oxide became practically inactive in a very short time. Mr. H. E. Copp, of Hull, discussing the effect of effluent liquor on fish life, queried which have the worse effect—the toxic constituents or the oxygen-absorbing compounds. His study of the problem indicates that the blame is to be placed on the phenolic bodies. How direct recovery of ammonia might assist the effluents problem was explained by Mr. L. H. Sensicle, of Newcastle-on-Tyne, who suggested that this phase of the subject should receive particular attention from the Committee. The effluent from the direct recovery process, he said, contains monohydric phenols, which can be removed by benzole washing; and the other substances are harmless, and do not enter into the question. Mr. Botley said that the Committee had by no means lost interest in the direct recovery process.

The full report of the Committee, together with the ensuing discussion, will be published later in the "JOURNAL."

Health Value of Gas.

The Report of the Gas for Therapeutical Purposes Research Committee, which was then introduced by Dr. E. W. Smith, the Chairman, was disappointing in view of the high hopes which had been entertained in the employment of gas as a direct curative agent. However, the work is in its earliest stages, and it may prove ultimately that radiation obtainable by gas is of definite value in this respect—in which case, as Dr. Smith observed, a considerable consumption of gas in sanatoria would ensue. There is, though, another aspect of the matter. The very fact that one of the leading specialists of to-day is enthusiastic about gas is bound to create a beneficial atmosphere in the medical profession.

The investigation was carried out by Sir Henry Gauvain at Moreland Hall, Alton; and he had the collaboration of the South Metropolitan Gas Company, who, as is well known, have for the past few years made an intensive study of this problem. The aim of the Committee was to provide, by means of gas, a number of sources of different types of radiation, so that, by correct blending, Sir Henry Gauvain could experiment on his cases. The sources tried were the radiations from a daylight mantle, daylight mantles with suitable filters, and gas fire radiants. So far, Sir Henry has found nothing of definite therapeutic value in the gas heating and lighting equipment tested; but he states that "heating by means of large cluster inverted burners is convenient and pleasant, and will enable treatment by means of ultra-violet light in the open air to be prosecuted with advantage," and he intends to employ gaseous heating in connection with further research.

The President is of opinion that we may be on the verge of some great discoveries in the application of gaseous heat; and he mentioned the case of a lady who found that exposure to the radiation from a gas fire relieved the pains of neuritis. The report was adopted on the proposition of Mr. S. Glover, of St. Helens, seconded by Prof. Cobb; and it was decided that the thanks of the Institution should be sent to Dr. Carpenter and the South Metropolitan Gas Company for their help in this work.

Report of Wrought-Iron Tubing Committee.

At this stage in the proceedings, the report of this Committee was presented—see our "General Report."

Education in the Industry.

The Report of the Gas Education Committee was presented by Mr. John Terrace, in the unavoidable absence of the Chairman, Mr. Goodenough. The year has been marked by three steps in the development of the Education Scheme—the setting-up of District Gas Education Committees; the acceptance by the Institution of the principle that possession of the Higher Grade Certificate and the Diploma

DR. E. W. SMITH.

F. W. GOODENOUGH, C.B.E.

shall help to secure the holder admission to membership of the Institution; and the holding by the Board of Education of a week's course of training for teachers. With regard to the number of candidates entering for Institution examinations, though there is an increase which indicates steady growth, hopes in this respect have not been entirely fulfilled; and for this reason the active support of members of the Institution was again requested. Only by persistent effort can the Scheme succeed as it should do. The Scheme appears to have much more attraction for students on the manufacturing side of the industry than for those engaged in distribution and sales; for, while no fewer than eighteen have qualified to sit for the Diploma in Gas Engineering, there are only three—and these the first three—entries for the Diploma in Gas Supply. Disappointment is expressed in the report that so few students—eighteen, compared with sixteen in 1927—have entered for the Higher Grade in Gas Supply. To put the matter in a nutshell, while in every direction there has been progress, the position still falls short of the necessities of the industry.

Report of the Livesey Professor.

The comments of Prof. Cobb on the Report of the Livesey Professor at Leeds University, which brought Wednesday's session to a close, will be found in our "General Report."

Effect of Temperature on the Reactivity of Coke.

The first item when the meeting was resumed on Thursday morning was the Report of the Institution Gas Research Fellow, Mr. F. J. Dent, who, under the supervision of Prof. Cobb, by whom the report was introduced, has been studying the effect of temperature on the reactivity of coke in steam. It was found that coke (with and without the addition of inorganic constituents) prepared at 800° C. had the maximum reactivity; the reactivity of 500° C. coke was distinctly lower; and the reactivity of 1100° C. coke lower still. At all temperatures the influence of the inorganic constituents was to enhance the reactivity. Mr. Dent also studied the influence which the presence and decomposition of hydrocarbon and other gases, in contact with coke at high temperatures, may exercise; and the effect on the reactivity in carbon dioxide of previously treating a "pure" coke with hydrogen, carbon monoxide, methane, or ethylene for one hour at various temperatures was ascertained. Treatment with methane lowered the reactivity in a very marked degree, and ethylene had an even more considerable effect.

F. J. DENT, B.Sc.
The Gas Research Fellow.

Prof. Cobb explained that the results of the work show that, when a coke is prepared and held at a certain temperature, further heat treatment for some hours in a neutral atmosphere such as nitrogen does not materially affect its reactivity. If, however, the coke is subjected to the action of hydrocarbon gases, particularly at temperatures from 700° C. upwards, the reactivity of the coke is impaired, even when the extent of decomposition of the hydrocarbons is small. If much deposition of bright "methane" carbon takes place on the coke, the effect is much more marked, and persists very much longer while the carbon is being gasified.

The second part of the report is concerned with the influence of inorganic constituents on the liberation of sulphuretted hydrogen; the work having been carried out by Mr. J. J. Priestley, under the supervision of Prof. Cobb.

Applications of Chemistry to Gas-Making.

It is obvious that the paper by Mr. Harold Hollings, M.Sc., the Chief Gas Chemist to the Gas Light and Coke Company, who was ably assisted in its compilation by Dr. S. Pexton, is the outcome of careful and continued research undertaken by the Research Department of the Gas Light and Coke Company, which was instituted four years ago, and which has already more than justified its inception. Every paragraph of the contribution, which is of great educational value, particularly to the junior members of the industry, embodies a vast amount of study. The outstanding impression we have after hearing Mr. Hollings, who presented the paper after the Gas Fellowship Report on Thursday morning, is the great possibilities of applying the results of laboratory investigation—always provided, of course, that there is close co-operation between laboratory and works plant—to the reduction of carbonizing costs; and we surmise that the Research Department of the Gas Light and Coke Company is doing as much to give the consumer cheap gas as is any other section of the Company. The paper, too, is a complete vindication of the value of the inductive method of considering large-scale working results.

HAROLD HOLLINGS, M.Sc.

Multum ex Parvo.

It is extremely interesting, for example, that in an attempt to reduce the free carbon content of tar produced by carbonizing coal in horizontal retorts, by increasing the weight of the charges, the yield of gas in therms per ton of coal increased from 70·7 to 71·6, while the carbonizing wages in pence per therm decreased from 0·413d. to 0·379d., despite a slight increase in wages rates during the period. This alone illustrates in no uncertain fashion how co-operation between the laboratory and the works influ-

ences the balance-sheet. Similarly, in a study of the thermal yields of gas resulting from oil cracking, it is seen that the efficiency of cracking varies with the rate of oil injection into the carburettor. Laboratory investigation shows that, with a correctly designed carburettor, one gallon of oil would yield 1·4 therms of gas; and this result has been obtained on a large-scale unit with low rates of oil feed. The laboratory work points to the fact that in carburetted water gas plants as at present designed there is probably insufficient checker-brick area, and that consequently they work at their highest efficiency, from the oil cracking point of view, only when using comparatively small quantities of oil and producing a gas of low calorific value.

Coal Gas Leakage from Retorts.

In another part of the paper is to be found a valuable inductive method of determining the amount of coal gas leakage from the retorts into the combustion chamber. The method is based on a simple waste gas analysis—determination of the carbon dioxide and free oxygen contents—and the validity of the method is demonstrated by a complete weight balance for the producers, combustion flues, and waste-gas system of a vertical retort installation. The extent of the leakage when retorts are charged is shown by a graph of the carbon dioxide content of the waste gases. This is the sort of information the industry wants; and it points to the paramount need for studying pressure conditions, and the porosity of refractory materials—particularly jointing cements. The leakage from horizontal retorts may be as much as three or four therms per ton of coal carbonized, which is of no small moment.

"Therms per Ton" in Verticals.

Another point. In the study of the working results of vertical retorts, it is difficult to differentiate between the respective yields of coal gas and water gas; and in the paper a method is outlined for assessing the coal-gas thermal yield—the only assumption which is made being the calorific value of the inert-free coal gas. From a study of coal carbonization in horizontal retorts, it is found that the calorific value of the *inert-free* coal gas varies within comparatively narrow limits. It would appear that the leakage is greater in verticals than in horizontals, unless porous coals are being carbonized.

Reducing the Costs of Sulphate Production.

A further extraordinarily good example of how laboratory results can be turned to practical account relates to ammonia recovery. As the outcome of a study of the vapour-pressure relations, a recovery system has been developed in which no additional water is required. This means at once a great saving in transport charges of the liquor and in the distillation costs for steam at the sulphate plant—a saving in the latter case of between 15 and 20 p.ct.

Much more could be written concerning this paper, for it is most suggestive. It leads us to expect further contributions, in greater detail, of many of the questions treated briefly on this occasion.

The discussion which the paper evoked was full of interest and suggestion. Naturally, the question of coal gas leakage from retorts called for much comment. As the President remarked, few gas engineers realize the extent of this leakage, which affords another indication of the necessity for scientific control in a gas-works. Dr. Parker, who pointed with gratification to the fact that the author had acknowledged and utilized the work detailed in the Twelfth Report of the Research Sub-Committee of the Gas Investigation Committee, suggested that the future may see the adoption of alloy retorts of smaller section, even if their use entails a slight reduction in carbonizing temperature.

The Water Gas Content of Vertical Retort Gas.

Mr. Sensicle observed that caution should be exercised in applying Mr. Hollings' method of assessing the relative amounts of water gas and coal gas in vertical retort gas. The stone content of certain coals contains matters which give rise to a gas yield of remarkable quantity. The shaley stone separated from a certain coal had an ash content of 78 p.ct., a volatile content of 14·5 p.ct., and a fixed carbon content of 5·5 p.ct.; and this stone, when carbonized at 1100° C., gave nearly 18 therms per ton of a gas of 372 B.Th.U. per c.ft. The volumetric yield was 4750 c.ft. Analysis of the gas showed the presence of hydrocarbons and water gas presumably produced from the water of constitution of the mineral matter.

The question of oil cracking was discussed by Mr. J. P. Leather and Mr. T. F. E. Rhead. The former called attention to his work carried out twenty years ago, the results of which, he said, precluded any claim of novelty by Mr. Hollings. Mr. Rhead had a great deal to say, and found the time at his disposal sadly inadequate. Having foreshadowed the possibility of multiple stage carbonizing, he turned his attention to methods of gas analysis, which, ordinarily carried out, are apt to be misleading. Waste gas analysis, the utility of which was pointed out by Dr. Parker, calls for skilled manipulation and scientific interpretation. At Birmingham the method has been correlated by pumping waste gases into the retort at scurfing time; and the effect of scurf in reducing leakage is astonishing.

Prof. Cobb remarked that the fact that Mr. Hollings, who was Gas Research Fellow in 1913 and 1914, now occupies a position of great responsibility with the largest Gas Company in the world, is a good omen for the scientifically trained men in our industry. Mr. Hollings' contribution is indicative of the service the properly trained chemist can render.

Gas out East.

Mr. S. B. Johnson's interesting narrative of "Gas Supply East of Suez" was taken as read. Mr. Johnson, who is Chief Engineer to the Colombo Gas Company, has had fifteen years' experience at Colombo, which has been termed the dustiest city in the East, and the climate of which he describes as akin to that of an English greenhouse. In

S. BARKER JOHNSON, M.I.Mech.E.

the early part of his paper he dispels the illusion that gas supply out East has little in common with the West. There are the same, and other, difficulties; there is the same need for constant energy and vigilance to maintain the supply and encounter competition successfully; and there has to be greater reliance on one's own resources. And at the end of his fascinating story, the author advises no man who dislikes hard work to leave the Home Country, for he has seen too many instances of men who, under the spell of the East, have taken the line of least resistance, and have thrown away their careers. On the other hand, the East offers splendid opportunities for the determined man who is capable of wide sympathy.

The present gas output at Colombo is 271 million c.ft.

a year; and the increase during the past nine years has amounted to practically 220 p.ct. This is astonishingly good when it is borne in mind that the competition from electricity, which is sold at 7d. a unit for lighting, and 2d. for power, is strong, and that gas in the Tropics labours under a difficulty on account of its heat. In cold climates the heat generated by an incandescent burner is an advantage; in hot countries the reverse holds. Another disadvantage is the insect and dirt nuisance; and Mr. Johnson observes that in some quarters the arc lamp globes on the street lamps are nearly one-third filled with flies in the night. There can be no question that the gas engineer in the East has to be very keen in his attention to maintain an efficient gas supply.

Extraordinarily Good Working.

Having dealt with the disadvantages of gas in the Tropics, Mr. Johnson goes on to explain the carbonizing methods employed at Colombo, and to give an account of the improvements which had been effected in the gas-making plant at the Colombo Works during recent years. He obtains the remarkable yield of 89 therms a ton, with ordinary horizontals, when carbonizing Indian coal; and equally remarkable are his figures for fuel used for heating the setting. When we heard of the latter figure, we at once thought of the possibility of gas leakage from the retorts helping to reduce the fuel account; but the gaseous thermal yield indicated that substantial leakage could not have taken place. We agree with the author that "there are few English works returning with ordinary horizontals such a high yield of gas," and congratulate him on his result. Naturally the low fuel consumption has a beneficial bearing on sales of "residuals." In 1926 the latter represented just over 100 p.ct. on the cost of coal carbonized, and last year the figure was 92 p.ct. In other words, the price the Colombo Company obtain for their coke and tar practically pays for all the coal they use. Wages are low in Colombo; a stoker is paid 2s. 2d. a day, and ordinary labour costs 1s. 2d. per day of nine hours. Thus retort house costs are small—last year they were well under 1d. per 1000 c.ft. of gas made.

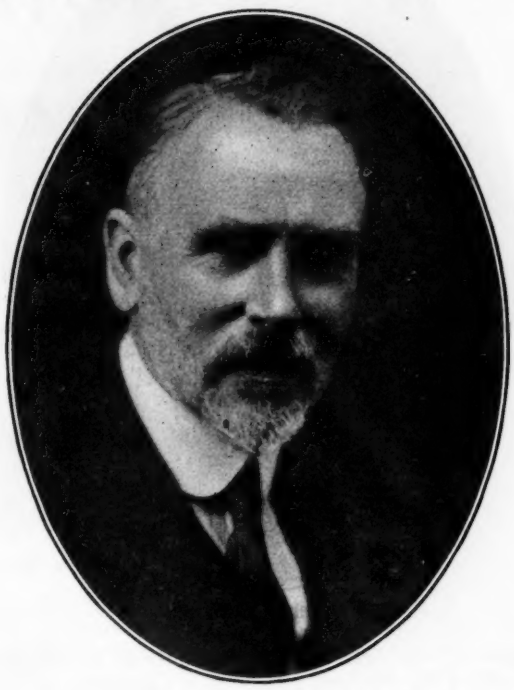
Gas Lighting in Colombo.

Following the description of the engineering extensions carried out at Colombo during recent years, the author turns his attention to distribution, and mentions, *inter alia*, that the private lighting load of his Company has increased by 75 p.ct. during the past six years. The natives prefer gas light to electric; but when it comes to gas cooking, they have a prejudice which is not hard to understand. When coal fires are used, they get a daily "commission" on the purchase of firewood; alas, gas cookers require no firewood! However, while records a few years ago show that the number of cookers out in the town was fifty, to-day there are nearly 2000.

Mr. Johnson is a great believer in gas for lighting, particularly for public lighting; and his account of how he has improved the street illumination of Colombo is stimulating. He is, also, an equally great believer in the value of advertising, and never begrudges a penny he spends in this direction. After reading his paper, we can easily understand why it is that the Colombo Gas Company is enjoying such progress. It is because their basic policy is to keep abreast of the times, and because this aim—thanks to an Engineer of foresight and virility—is effectively translated into practice.

Refractory Materials.

The Report of the Refractory Materials Joint Research Committee was then presented by the Chairman, Mr. John P. Leather, who thinks that gas engineers generally do not pay enough attention to the important question of refractories. Though the financial position of the British Refractories Research Association has led to a smaller research staff, much good work has been done during the year. The report is a review of this work, and in addition contains a special communication, by Messrs. A. J. Dale and A. T. Green, on the thermal insulation of retort settings. Mr. Leather observed that the loss of heat from a setting, especially from the metal work, is high; and it is advisable to design settings with a view to minimizing heat losses, rather than to add a blanket of insulating material as an afterthought. The latter method implies a rise in temperature of the walls. It is



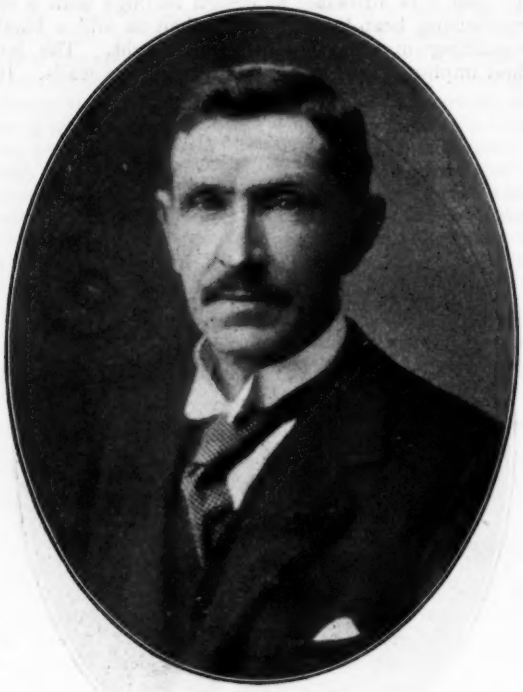
JOHN P. LEATHER, M.Inst.C.E.

surprising what a large amount of heat is radiated from metal sight-boxes; and Mr. Leather exhibited a simple sight-hole plug made out of Moler brick by the foreman at the Stretford Gas-Works. It was mentioned that during the year the Committee had given further consideration to the clauses relating to the after-expansion of silica material in the Specification of The Institution of Gas Engineers.

Other Reports.

Next came the Interim Report of the Coal Analysis and Sampling Committee of the British Engineering Standards Association, which was presented by Mr. W. J. Smith, B.Sc., of Bolton; and following this were the

W. J. SMITH, B.Sc.



ROBERT WATSON.

Reports of the International Commission on Illumination and of the National Illumination Committee of Great Britain, presented respectively by Mr. Robert Watson, of Doncaster, and Mr. Fras. C. Briggs, of Dudley.

JOHN TERRACE, M.Inst.C.E.
Elected President for 1928-29.

The President's Certificate.

In a charming speech, Mr. John Terrace, as President-Elect, then handed to Mr. Madden the President's certificate. The work of Mr. Madden, who possessed tact and courtesy, constituted his own monument; and, said Mr. Terrace, the whole of the Council were grateful to their President for the excellent way in which he had guided their deliberations. He would go down to posterity as the President in whose year it had become possible for the Institution to alter its rules and apply for a Royal Charter —a culmination largely due to his personality.

Place of Next Meeting.

The formality was then gone through of deciding, on the proposition of Mr. Terrace, to hold the next annual meeting of the Institution in London.

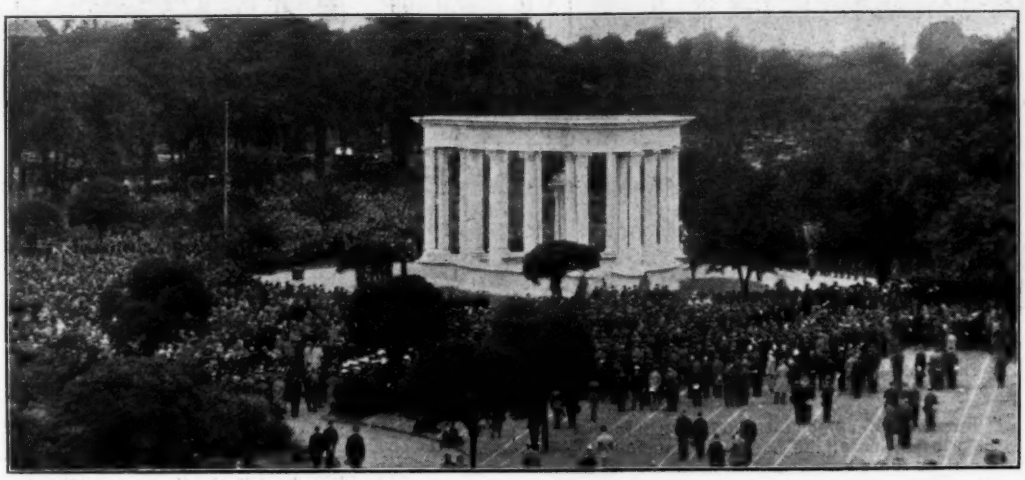
Votes of Thanks.

The business of the meeting terminated by a series of votes of thanks. The first vote—to the Lord and Lady Mayoress of Cardiff—was proposed by Mr. Terrace and seconded by Mr. C. S. Shapley; the Chairman and Directors of the Cardiff Gas Light and Coke Company were thanked on the proposition of Mr. J. H. Canning, seconded

CHAS. S. SHAPLEY.
Senior Vice-President.

by Mr. Ferguson Bell. A vote of thanks to the Reception Committee, proposed by Mr. Andrew Wilson, of Sydney, and seconded by Mr. Samuel Glover, was acknowledged by Mr. Octavius Thomas; and Mr. Madden, of course, replied to the vote to the President and Council of the Institution, which was proposed by Mr. Ralph Halkett and seconded by Mr. W. H. Warren, of London. Acknowledgment of the vote to the Research Committees and the Education Committee—proposed by Mr. C. G. Dawson and seconded by Mr. W. Clark Jackson—was made by Dr. E. W. Smith and Mr. Terrace; and of the vote to the other officers and to the staff of the Institution—proposed by Mr. W. B. McLusky, of Halifax, and seconded by Mr. Thomas Carmichael—by Mr. W. E. Price, the Hon. Secretary. The final vote of thanks was to the Technical and Daily Press, on the proposition of Mr. Frank West, seconded by Mr. S. Meunier, of Stockport; and Mr. Clifford A. King ("GAS JOURNAL") responded.

SOCIAL EVENTS.



THE WELSH NATIONAL WAR MEMORIAL.

The week was a busy one, alike from the business and the social point of view. The programme promised much; but in this case realization even exceeded anticipation. The Reception Committee and the Ladies' Reception Sub-Committee did their work well—so well, indeed, that there was no chance of a dull moment during the meeting, either for the members or for the ladies who accompanied them. It should, in fact, be said at once that a feature of the meeting was the completeness of the arrangements made for entertaining the ladies, in which part of the programme Mrs. Madden made herself as popular as did the President on his side. The ladies learned much about Cardiff during their stay; and the better they came to know it, the more they liked it. Of the quarter of a million and more of the inhabitants, they met many; and they found that Cardiff's beauty is not only skin deep. The same things, of course, were made equally obvious to the members; but they possibly, as business men, were more impressed by the commercial importance of a city whose rise to fame may be regarded as one of the romances of industry.

DINNER TO THE PRESIDENT AND COUNCIL.

The proceedings of the meeting may be said to have opened on Monday evening, June 11, when the Cardiff Gas Light and Coke Company gave a complimentary dinner to the President and Council of the Institution, in the Whitehall Rooms of the Park Hotel. Mr. Lawrence G. Williams (the Chairman of the Company) presided, and had Mr. Madden and the Deputy Lord Mayor of Cardiff on his right hand, and Sir David Milne-Watson on his left. Nothing was lacking that could contribute to the enjoyment of those who were privileged to be present. A full report of the speeches will be found on another page of this issue.

MRS. MADDEN "AT HOME."

At the Angel Hotel, on Tuesday afternoon, Mrs. Madden was "at home" to the lady visitors, who numbered about 200. Mrs. Madden (attended by her daughters, the Misses Kathleen and Nancy Madden) carried a bouquet of pink carnations, which was presented by Miss Peggy Auckland, on behalf of the staff and workmen of the Company. The "at home" was a very happy idea; and those who accepted the invitation had the pleasure of meeting old friends, and making new ones, from different parts. The guests filled the ballroom and the surrounding lounges; and music and refreshments were provided for the guests, who found the function a highly attractive one. Mrs. Madden, too, was charmed with its success.

LUNCHEON TO THE RECEPTION COMMITTEE.

Another equally delightful informal function followed the morning session on Wednesday—after the members and ladies had assembled outside Cory Hall for the taking of a panoramic photograph of all attending the meeting. This was a luncheon at the Park Hotel to the Reception Committee, by invitation of the President. Mention has already been made of the thoroughness with which their task was performed by this Reception Committee—consisting of the President (Mr. D. Walter Davies) and Council of the Wales and Monmouthshire District Institution of Gas Engineers, together with Mr. W. E. Price and Mr. Walter T. Dunn, Hon. Secretary and Secretary respectively of The Institution of Gas Engineers. This was freely acknowledged at the luncheon, during the course of which Mr. Octavius Thomas (Hon. Secretary of the Reception Committee) was toasted no less than three times, and there

The Institution's Wreath.

were affectionate references to "Uncle Bill," whose identity it is unnecessary to divulge here.

RECEPTION AND DANCE.

Then on Wednesday night came the culminating social event of the week, when the Lord Mayor and Lady Mayoress of Cardiff (Alderman A. J. Howell, J.P., and Mrs. Howell) entertained over 600 guests in the City Hall, Cathays Park. It was a memorable evening. The Cardiff City Hall, with its pictures and statuary, and also its immense Assembly Room, with hung floor, is alone sufficiently magnificent to make a lasting impression; and when to this luxuriousness is added the warmth of hospitality which marked last Wednesday's function, the

THE CIVIC RECEPTION.

The Lord Mayor and Lady Mayoress, Miss Howell, the President and Mrs. Madden, and the Misses Madden.

occasion must prove a never-to-be-forgotten one. Indeed, it was stated to have been one of the most brilliant and largely attended civic functions that has taken place in the city in recent years. Ascending the broad stairs for the reception, the guests found awaiting them in the Marble Hall, and facing the ball-room entrance, the Lord Mayor and Lady Mayoress, with Miss Howell, and the President and Mrs. Madden. Subsequently, latecomers were received in the ballroom, where the ladies and gentlemen just referred to, and the Misses Kathleen and Nancy Madden, were seated on a dais under the musicians' gallery. Quite early in the evening there was a pretty little ceremony performed by five gentlemen who walked down the room in procession carrying handsome bouquets which they presented to the ladies on the dais. The Lady Mayoress was given a bouquet by Mr. John Terrace, on behalf of the Institution; while her daughter, Miss Howell, received one at the hands of Mr. W. E. Price. Mrs. Madden was handed her bouquet by Mr. D. Walter Davies (President of the Wales and Monmouthshire District Institution); Miss Kathleen Madden, by Mr. T. V. Blake (President of the Wales and Monmouthshire Junior Association); and Miss Nancy Madden, by Mr. A. E. Martin.

Dancing commenced shortly after 8 o'clock, and proceeded gaily until about 2 a.m. While it was in progress, the scene was one of great brilliance. Masses of pink hydrangeas were banked in the alcoves round the wall; while over the heads of the dancers were threaded rows of various coloured fairy lamps.

Next morning there were many references to the happy time that had been spent in Cardiff's famous municipal building.

TINTERN, MONMOUTH, AND BRECON.

All mundane things have an end; and an end had to come to the Cardiff conference. But it was an end which was worthy of all that had gone before. Early on Friday morning, the large number of members and ladies who had found it possible to remain for the outing assembled outside the City Hall, from which a start was to be made on a long motor coach tour to view some of the most beautiful and interesting features of the district. Before setting forth on the journey, they were afforded yet another example of the large-heartedness which seems to pervade Cardiff; for the Lord Mayor, who had already devoted so much time to the visitors in an amazingly busy civic week, was there to bid them "Good-bye," while the Lady Mayoress accompanied the party on the tour. An article by Mr. J. H. Canning, of Newport, entitled "When the Institution Visit Cardiff," which appeared in the "JOURNAL" for June 6, and described the proposed course, had whetted the appetites of the travellers. They had learned something of what they were to see from the fluent pen of a well-informed and devoted writer; but it is no reflection upon Mr. Canning to remark that the charms of some mistresses are so great that even the most eloquent lover cannot hope to do them full justice. The greater part of the day was gloriously fine; and the few showers which

THE LORD MAYOR OF CARDIFF.

THE LADY MAYORESS.

OUTSIDE THE CARDIFF CITY HALL.

fell during the return journey merely served to emphasize the good fortune which had attended the outward run. Readers will still have Mr. Canning's descriptive article in mind, and will remember that the first stage (one of 33 miles) was to Tintern, where there was a pause to view the world-famed Abbey. Then the drive was resumed for another 11 miles to Monmouth, where another civic welcome awaited the visitors, who were met at the Rolls Hall by the Mayor.

In the hall a party of about 250 sat down to an excellent luncheon, after which the President proposed "The King, our Prince, and the Royal Family." He was followed by Mr. E. H. Perkins, a Director of the Monmouth Gas and Water Company, who submitted "The Institution of Gas Engineers," and welcomed the visitors to the Royal and Ancient Borough. Mr. Madden, in the course of his reply, paid a tribute to the Lord Mayor of Cardiff, the Lady Mayoress, and Miss Howell, who had done so much to make the conference a success. He also thanked the Mayor of Monmouth, Mr. Perkins, and other representative local gentlemen present, for their kindly welcome, and for the assistance they had rendered in arranging the programme. Mr. J. Terrace proposed "Prosperity to the Town and Trade of Monmouth;" and the Mayor (Alderman C. Hancocks) replied. He invited the visitors to inspect in the museum the collection of Nelson relics, supposed to be the finest in existence. Proceeding, he said he felt bound to pay a little tribute to the local Gas and Water Company, who were becoming very up to date in their services to the town of Monmouth.

After lunch the drive was resumed for 35 miles to Brecon, where tea was served; and then there was a return journey of 42 miles to Cardiff.

BUTE LODGE, NO. 960.

On Monday, at 6.30, a Special Emergency Lodge was held in the Masonic Temple at Cardiff to welcome the masonic brethren of The Institution of Gas Engineers.

The Worshipful Master, W.Bro. W. E. T. Davies, was in the chair, and was supported by the Deputy Provincial Grand Master, W.Bro. D. J. Jones, and the whole of the regular officers of the Lodge.

The Lodge having been opened in due form, the W.M. cordially welcomed the visitors.

A ceremony of initiation was then proceeded with.

At the conclusion of the business of the Lodge, the visitors and brethren proceeded to the Banqueting Hall for supper. The Loyal and usual masonic toasts having been duly honoured, the toast of "The Visitors" was proposed by W.Bro. J. Sidney Rees, the Treasurer of the Lodge, and responded to by W.Bro. A. L. Croager (W.M. of the Evening Star Lodge); W.Bro. Shadbolt (of the Northern Star Lodge), W.Bro. D. J. Jones, Deputy Provincial Grand Master, and others.

A most enjoyable musical programme then finished the proceedings.

THE LORD MAYOR BIDS THE VISITORS GOOD-BYE.

THE RECEPTION COMMITTEE

1. Mrs. H. A. Bond (Port Talbot).
2. Mrs. Mogford (Cardiff).
3. Mrs. D. Walter Davies (Tredegar).
4. Mrs. W. Collin (Bridgend).
5. Mrs. A. Kyle (Abergavenny).
6. Mrs. H. D. Madden (Cardiff).
7. Mrs. Auckland (Cardiff).
8. Miss Madden (Cardiff).
9. Mrs. Canning (Newport).
10. The Lady Mayoress of Cardiff.
11. Mrs. A. E. Williams (Cardiff).
12. Mrs. Jackson (Neath).
13. Mrs. M. Jones (Dowlais).
14. Mrs. Grainger (Caerphilly).
15. Miss Edna M. Johns (Swansea).
16. Miss M. K. Thomas (Rhondda).
17. Mrs. Boardman (Cardiff).
18. Mrs. J. E. Kenshole (Merthyr Tydfil).
19. Mrs. Swain (London).
20. Mrs. W. H. Johns (Swansea).
21. Miss Nancy Madden (Cardiff).
22. Miss I. Kenshole (Merthyr Tydfil).
23. Mrs. E. M. Lofthouse (Pontardawe).
24. Miss G. Kenshole (Merthyr Tydfil).

FOR THE CARDIFF MEETING.

1. B. Grainger (Caerphilly).
2. A. E. Williams (Cardiff).
3. A. J. Bond (Port Talbot).
4. T. E. Franklin (Barry).
5. T. B. Pearson (Pontypool).
6. W. E. Price (West Chobham).
7. W. Collin (Bridgend).
8. F. Boardman (Cardiff).
9. W. Clark Jackson (Neath).
10. H. D. Madden (Cardiff).
11. D. Walter Davies (Tredegar). Chairman.
12. W. H. Johns (Swansea).
13. J. H. Jones (Dowlais).
14. J. E. Kenshole (Merthyr Tydfil).
15. J. H. Canning (Newport).
16. A. T. Kyle (Abergavenny).
17. O. Thomas (Rhondda).
18. E. H. Swain (London).
19. R. J. Auckland, A.C.I.S. (Cardiff).
20. J. Mogford (Cardiff).
21. A. G. Lofthouse (Pontardawe).

VISITS TO WORKS.

VISITORS AT GRANGETOWN.

On the Wednesday afternoon, alternative visits had been arranged to the British Mannesmann Tube Works at Newport; the Cymmer Collieries at Porth, Rhondda; and the Dowlais-Cardiff Steel Works; while on Thursday afternoon there was a big assembly for an inspection of the Cardiff Gas Company's Works at Grangetown. In addition to this, the showrooms of the Company in various parts of the city were open to members during the whole of the meeting.

BRITISH MANNESMANN TUBE WORKS.

The members of the Institution have from time to time visited works and factories in various parts of the country with varying degrees of interest; but one can safely say that the 120 odd members who journeyed to the Newport Works of the British Mannesmann Tube Company carried away an impression which it will be difficult to efface. Setting off from the City Hall in motor coaches provided by the Company, under the guidance of Mr. W. J. Allen, of the London Office, the members were prepared for an enjoyable afternoon by a 14 mile drive through lovely scenery, enhanced by glorious sunshine.

On arrival at the works, the party were met by Messrs. Gordon, Bevan, Smith, Hunter, Fowler, and Powell, who thereupon divided them into sections and conducted them on a tour of the works. After a brief visit to the power station, the parties saw the most up-to-date processes of tube making, whereby ingots of varying sizes are converted into tubular form.

The ingots are heated in large furnaces to a white heat, and mechanically conveyed to the piercers, where they are rotated at high speed in specially designed rolls, and are at the same time forced over a piercing head; this action converting a solid ingot into a hollow "bloom"—a rough form of tube. The hollow bloom, without further heating, is then passed to the rolling mill, where is inserted a mandrel bar of the same diameter as the bore of the tube to be rolled. The bloom is then forced forward in steps through gaped rolls, the action of which is to swage or roll it down to the diameter and thickness required in the finished tube. By this operation, the material is rolled out to a length of 50 or 60 ft., or even longer, according to the original weight of the ingot and the section of the finished tube.

The tube thus formed has one end ragged, and the other thickened—so fashioned by the finishing curve of the rolls—and it is the adoption of this thickened end which is such a valuable feature of the Mannesmann type of spigot and faucet joint. The tubes are next straightened and cut to length, after which the joints are formed, before being tested hydraulically to pressures up to 1000 lbs. per sq. in. or more. The pipes are then conveyed to the dipping tank, where, by immersion in a heated bath of special bituminous solution, they are coated inside and outside, or outside only, according to the requirements of the case. As a further means of protection, the pipes are finally wrapped in spiral fashion with jute cloth saturated in the same solution.

These are the methods generally adopted by this firm for weldless steel tubes. The British Mannesmann Company are able to supply these at present up to 13 in. bore, and shortly will be in a position to provide weldless pipes with an internal diameter of 14 in.

The next step was a visit to the lapweld department, where pipes from 15 in. up to 80 or 90 in. diameter are made. This process was somewhat familiar to a number of the members; but they were able to see pipes which had been made for the Manchester Gas Department and the Bournemouth Gas and

A GROUP ON THE WORKS.

Water Company. Although most of the party were chiefly concerned with mains, another interesting feature witnessed was the drawing-down and stepping of tubes to be used for lighting and tramway poles, derricks, davits, &c. It is worth mentioning that the Company make all these in one length; the tapering or stepping of the pipes to diameters which are determined by the loads to which they are subjected being carried out on a specially designed draw bench.

Following this a brief inspection was made of the " specials " department, where branch welding, bending, &c., is carried out; and then they saw the screwing department. This is a magnificent building containing the latest machines for dealing with pipes required for oilfields, for hydraulic work, &c. It was pointed out that the building in which these machines are housed is dustproof; automatic shutters closing after the entry of each tube, so as to prevent any grit getting into the very fine threads.

At this point, time necessitated the closing of the tour of inspection; and the visitors were conveyed to the King's Head Hotel, at Newport, where tea had been provided by the Company. In a few brief remarks, Mr. Allen conveyed to the members the thanks of the British Mannesmann Company for the honour which the Company felt had been conferred upon them by this visit. He said he was very glad this opportunity—when the Institution met in South Wales for the first time in its history—had enabled them to give facilities for the gas engineers of this country to see for themselves how British Mannesmann weldless steel tubes were made. He hoped the members had spent an interesting and enjoyable afternoon. If time allowed, and members cared to do so, his principals would be very pleased to allow them to visit their Landore Works, Swansea, where pipes from ⅛ to 6 in. diameter are produced. The Newport Works were particularly concerned with tubes of from 7 in. upwards.

Before leaving, the visitors heartily thanked the Company for a very interesting experience, and expressed appreciation of the hospitality that had been extended to them. One member remarked that he had often wondered how the British Mannesmann Company produced their weldless steel tubes; but the actual demonstration he had witnessed left him with a lasting impression of the high-class quality of their product. It was evident that the steel which was used in the production of these tubes must be of the best possible quality to withstand the tremendous buffeting in the mill which converted the ingot into its tubular form. It may be remarked that Mr. Allen had explained to the visitors that, in order to provide suitable steel, their Associated Company, Messrs. Baldwins, Ltd., had designed special furnaces at Margam, Port Talbot.

CYMMER COLLIERIES.

The small party who proceeded to the Cymmer Collieries, at Porth, Rhondda, had little thought for the history of Cardiff Castle or for the beauty of the city's municipal buildings; but they were keenly interested in the Glamorgan Canal, which had brought coal from the hills to the seaboard before Stephenson designed the steam engine. The party noted Llandaff Cathedral in the distance, as they passed along the North Road; but their chief interest in Llandaff seemed to be the fact that one of its Bishops (R. Watson, D.D., F.R.S.) had written the first essay on " pitcoal," and had produced a quantitative analysis of coal by carbonization.

On arrival at the collieries, the visitors were received by Mr. W. Brynmor Davies (General Manager and Agent) and his deputies. They were then deprived of all matches, pipes, cigarettes, and tobacco, shed some of their conference apparel, and donned such other clothes as were available. There was not, however, sufficient emergency clothing for the whole party, and so a few decided that they would content themselves with examining the works above ground while the remainder were below.

Before going below, a tour was made of the surface works, including a methane compressor plant, the fans for ventilating the workings, steam accumulators, winding machinery, and haulage methods. Then a move was made for the shaft, where a safety lamp was handed to each member of the party. Entering the cage, the descent was begun; but the beginning and the end were so near to each other that at least one member of the party will ever remember the sensation. The drop of 430 yards, it is said, occupied about 40 seconds. There was a short stay at the bottom, to enable the party to become accustomed to the lighting facilities, before a move was made to the stables, where the short, thick-set ponies were examined. Their sleek coats and healthy appearance made it hardly credible that they seldom saw daylight. One veteran had been below for fourteen years.

Proceeding through the main roadways, the party were interested in the different methods of roof support. In some parts brick arching was found. Other parts were in stone-work; while further in timber supports were general. There were long stretches where the method of steel supporting arches had been adopted. The height of the roadway varied from 10 or 12 ft. to about 6 ft. After passing through doorways and hanging brattice cloths (used for diverting the air streams), the face was reached. The coal was being worked by means of compressed air-driven machines, and removed to the trams in the roadway by a conveyor. The distance from the shaft bottom to the coal face is about a mile. Returning from the face, a stop was made to watch a collier and his boy working a stall by mandrel and shovel. The thickness of the seam is about 3 ft. 9 in.; and it was interesting to see the man cutting and removing the coal, and the method of supporting the roof as he progressed. Finally the signalling arrangements at the pit bottom were inspected.

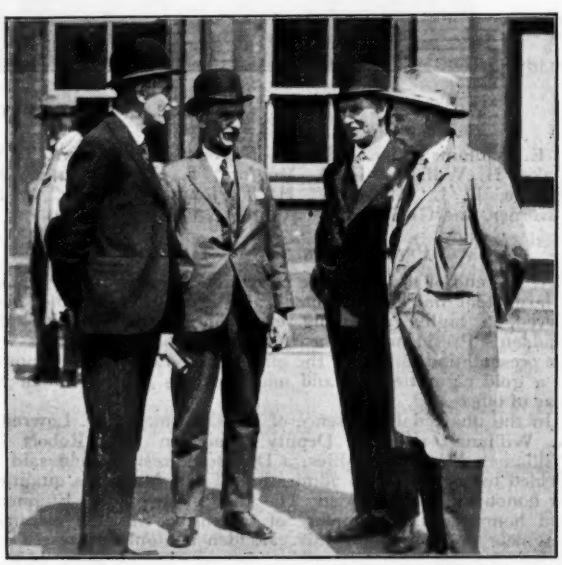
A return was made to the surface, where the screening plant was examined. Tea was then provided for the visitors, after which a hearty vote of thanks was passed to Mr. Brynmor Davies for an instructive afternoon.

DOWLAIS-CARDIFF STEEL WORKS.

It is doubtful whether any branch of the steel trade has had such a rapid growth in the last few years as that dealing with the manufacture of welded steel pipes. This Company was established in 1925 by Messrs. Guest, Keen, & Nettlefolds, Ltd. (whose steel works are the largest in South Wales), and by Messrs. Thomas Piggott & Co., Ltd., of Birmingham, wh were pioneers in the manufacture of welded steel pipes.

The works are situated in the precincts of Messrs. Guest, Keen, & Nettlefolds' Cardiff works, and within half a mile of the docks. They are therefore ideally placed for producing pipes at the lowest cost for home and export, from 14 in. to 72 in. in diameter, and in length up to 25 ft. The works are equipped with the most up-to-date welding and other necessary machinery and plant, so that customers can actually see the complete process of manufacture from the arrival of the iron ore at the docks to the rolling of the steel plates and the dispatch of the finished pipe. That is probably unique in this country.

Messrs. Guest, Keen, & Piggotts have carried out very large contracts, both for home and abroad, for gas-works, municipalities, and water boards. In addition to the manufacture of straight steel pipes, they can supply the necessary specials and valves, and also socket-and-spigot tubes; and all pipes are tested in a hydraulic proving press.



Friends at Cardiff.

With regard to coating, all scale and dirt is removed from the pipe before it is placed in a specially constructed heating chamber and brought to a temperature of 300° Fahr. From this it is taken and immersed in a bath containing bituminous composition. It is then removed and allowed to drain in a vertical position, after which it is taken to a machine and wrapped spirally with hessian cloth impregnated with bituminous composition. Pipes for export are rolled in sand or sawdust after coating, if desired.

Inspection is carried out by the Company's own staff at every stage of manufacture; and customers may appoint their own inspector, who will be given every facility for carrying out his duties.

GRANGETOWN GAS-WORKS.

Thursday afternoon was reserved for the inspection of the Cardiff Gas Company's Works at Grangetown, and the great majority of those who had been present at the business sessions took part in it. As an illustrated account of the works appears on other pages of this issue, it is unnecessary here to do more than just remark that the lay-out strikes one as expressing forcibly the large-mindedness which governs the policy of the Company in all respects. The President himself headed one party on the tour of inspection; and others who assisted him as guides included Mr. F. Boardman (Assistant Engineer), Mr.

THE EMPLOYEES' TRIBUTE TO THEIR CHIEF.

A. E. Williams (Superintendent of Works), and Messrs. T. V. Blake, H. Williams, G. A. Mogford, T. H. Madden, C. R. Monroe, L. L. Kliest, W. H. T. Johns, J. Wilde, A. R Taverner, and G. Shute.

PRESENTATION TO MR. MADDEN.

At one end of the extensive recreation grounds on the works, a large tent had been erected; and here, after tea had been served, a highly gratifying event in connection with Mr. Madden's Presidency of the Institution took place. This was the presentation to him by the officers and men of the Company of a gold cigarette case and matchbox, as a memento of his year of office.

In the unavoidable absence of the Chairman (Mr. Lawrence G. Williams) and the Deputy Chairman (Mr. Robert H. Williams), Mr. James Miles, a Director, presided, and said he yielded to no one in his admiration of Mr. Madden's qualities. In honouring Mr. Madden, The Institution of Gas Engineers had honoured the Company of which he was the esteemed Engineer and Manager. Mr. Madden not only possessed full technical knowledge of gas manufacture, but he knew how to get the best out of the men he managed. He did not think there was an undertaking in the kingdom in which a better feeling existed between the management and the men than was the case at the Grangetown Works. The Company would always do their best to cultivate this spirit. In conclusion, he expressed the hope that the visit of the Institution to Cardiff might be productive of much good, and that the President-Elect might have as pleasant a year of office as Mr. Madden had enjoyed.

Mr. George Gover, who has been for 35 years in the Company's employ, said that the Company and workmen followed with the keenest interest the deliberations of The Institution of Gas Engineers that week under the Presidency of their Engineer and Manager. As workmen they appreciated the honour conferred upon Mr. Madden, and were desirous of extending to him their congratulations.

Mr. James McCarthy, who has had over 53 years' service with the Company, then made the presentation. He remarked that it was the desire of all grades in the Company to present Mr. Madden with a souvenir to mark his Presidency, and they would be highly gratified by his acceptance of it. He then handed to Mr. Madden the gift, which was inscribed:

> H. D. Madden, M.Inst.C.E., President of The Institution of Gas Engineers, 1927-28. A souvenir of his Presidency and an expression of esteem from all grades of employees of the Cardiff Gas Light and Coke Company.

Mr. Madden, who was greeted with loud applause, in acknowledging the presentation, said it was difficult for him to express what he felt at that moment. Some 22 years ago he came to Cardiff, and found himself among friends. The intervening period had presented all kinds of difficulties; but he had never asked in vain for a job to be done. If he had been successful at Grangetown, he could only put it down to the loyalty of the employees. He would greatly treasure the gifts; and he trusted they would be spared to work together for many years to come. He thanked them very sincerely one and all; and he knew that his wife would appreciate the honour that had been done him as deeply as he himself did.

GAS COMPANY SHOWROOMS.

The Cardiff Gas Company have five showrooms in their district; and these are situated in convenient centres for the service of their consumers. Incidentally, they represent the different ideas in lay-out suggested by the progress of sales organization. As far back as 1856 the Company were alive to the desirability of displays of gasfittings, for in that year, when new offices were designed, provision was included for a showroom. When the present chief office was erected, in 1895, definite allocation of part of the building was made, and the Bute Terrace showroom arranged. Naturally, it still serves its purpose, although the types of fittings and appliances sold have entirely changed from the original displays.

As the city extended, necessity arose for a showroom in the chief business and shopping streets; and in 1910 the Queen Street showroom was opened. As these premises had to be altered, good window space was provided, enabling special displays to be made; and full advantage has been taken of this facility to bring to the notice of the public the value of gas and its uses. The internal arrangements include a department for the payment of consumers' accounts; and recently a special hot water show has been added, demonstrating various methods of obtaining hot water with gas appliances.

Penarth, being a separate township, had had a branch showroom in Windsor Road since 1903; but as this was not compatible with the growth of the business, premises were purchased and altered in 1925 in a manner which made the Penarth showroom, with its stone frontage and modern windows, a most attractive business centre. Besides being used as a showroom, the building is arranged as district stores, with a district office for fitters' work. It is interesting to note that last year 450 Sugg "Promenade" lamps replaced the old lighting system in the streets, with beneficial results.

On the other side of the district, the showroom in Church Road, Whitchurch, is typical of the modern tendency to make buildings suitable to the surroundings. As this is purely a good-class residential area, the white rough-cast buildings look particularly pleasing, and the squared glass panes of the showroom windows give a rural aspect to the premises. Arrangements are made for this showroom to serve as a district office, with a staff of fitters; and on the same site the transformer station is situated.

At Taffs Well station a small showroom serves that outlying district. A room in an existing building was allocated for the purpose, panelled, and made suitable for the display of the usual appliances.

GENERAL REPORT OF THE PROCEEDINGS.

THE PRESIDENT, H. D. MADDEN, ESQ., M.INST.C.E., M.INST.MECH.E., IN THE CHAIR.

[The Address, Papers, and Reports referred to will be found on pages following this report.]

The PRESIDENT (who was cordially greeted), on opening the proceedings, said: Ladies and Gentlemen,—It is a very busy day; and I will at once welcome the Lord Mayor of Cardiff. He has been exceedingly kind to come here. He has a very heavy day before him, with the unveiling of the Welsh National War Memorial by the Prince of Wales, and some big civil functions; and I look upon it as a great honour to my Company and myself that he should have come to welcome you.

A Civic Welcome.

The LORD MAYOR OF CARDIFF (the Right Hon. Alderman A. J. Howell, J.P.): I want in the first place, if I may, to make an apology to you for the absence of my wife this morning. As your President has pointed out, we have a fairly heavy day before us, and the Mansion House is full of visitors; so that the Lady Mayoress's time is very much taken up. I feel, therefore, that in the circumstances you will excuse her. ["Hear, hear."] I am very delighted to be here, as the Chief Magistrate of the City, to welcome you, and to support my own townsman in the Presidential Chair. [Applause.] We in Cardiff look upon it as a great honour that this important Institution of yours should have selected Mr. Madden for this high position; and, when he approached me in regard to this gathering, I had no hesitation at all as to what I should do in the matter. I assured him then that we should do our very best to make the delegates comfortable and happy, and to show them what a beautiful city we have in Cardiff. You do not want me this morning, I am sure, to make a speech on gas or the production of gas. I could do it, because I am continually between the four walls of a gas-works in the City Hall. There are different qualities of gas there, I can assure you; and you gentlemen might be able to help me to put some of that right, if I had time to talk to you. What, however, I do want to do this morning is heartily to welcome you. I have read part at any rate of the President's Address; and one remark in particular struck me, to the effect that "the aim of any progressive gas undertaking to-day is, or should be, to give the best possible service to its consumers." I feel that, if I wanted to address you at length, I could not take a better text than that. We do know that the gas industry in this country and in other countries is rendering not only a great service in the smaller ways of life, but is really rendering a great service in the larger things of life; and the way in which the industry has developed, so far as my memory goes, is really convincing. I not only welcome those from our own country, but I welcome very heartily those delegates who have come from other parts of the world. I want to assure you all that you are welcome in Cardiff, which we hope will one day be actually the recognized capital of Wales. But even should the city attain that dignity in years to come, you could not then get a better reception than you are having to-day. I hope to show you to-morrow night what we can do in the way of a civic function. I am very grateful to you, Mr. President, for having given me the opportunity of being here this morning; and I can only once again say that I hope your conference will be a great success from every point of view.

The Chairman of the Cardiff Gas Light Company.

The PRESIDENT: I shall now ask the Chairman of the Cardiff Gas Light and Coke Company to address to you a few words of welcome.

Mr. LAWRENCE G. WILLIAMS: On behalf of myself and my co-Directors of the Cardiff Gas Light Company, I have very few words to say; and I am not going to take up your time on a busy day like this. First of all, I think we ought to express our gratitude to the Lord Mayor for coming here to-day and extending such a hearty welcome to the Institution; and I would also like to thank him on behalf of the Directors of the Gas Company, to whom he has been so courteous. My colleagues and I cordially welcome you to the city; and we hope you will all be pleased with Cardiff and with your reception.

The PRESIDENT: My Lord Mayor, Mr. Chairman,—On behalf of the Institution, I would like to thank you for your very kind welcome to us this morning. We do appreciate very deeply indeed that you should both have come to take part in the opening of our proceedings. It is true that the Institution stands for public service, and research work to this end. We hope the conference will bring good, not only to the Institution, but to the consumers whom we serve. I thank you. We have made the Lord Mayor a member of the Institution this morning; and I have asked him, also, to accept a badge on behalf of the Lady Mayoress.

The LORD MAYOR: I thank you very much for your kind words. I have been asked to wear this badge to-day, now that I am a member of this Institution. I shall do it; and if the Prince of Wales asks me what it means, I shall simply tell him it means that I am a member of this great organization, The Institution of Gas Engineers. If I might give him a word of advice, I should say that he ought to belong to it too.

The PRESIDENT: He is an Honorary Life Member.

From Sister Organizations.

The PRESIDENT: I will now ask the Secretary to read out the names of delegates who are here from sister organizations, and also some communications that have been received.

The SECRETARY (Mr. W. T. Dunn): We have had the following telegrams:

> Belgian Gas Association send cordial greetings and best wishes to their English colleagues at their Cardiff assembly.—DE BROUWER, President.
>
> Gas and Water Association of Czecho-Slovakia send greetings and best wishes for successful meeting.—Vice-President, Dr. KECLIK.
>
> The German Institution of Gas and Water Engineers beg to wire their best greetings and wishes for a most successful meeting.—The President, KUEHNE.

The German Institution are meeting to-day, as are also the French gas engineers. The Belgian gas engineers have also forwarded a letter which I need not read, because it conveys the same sentiments as the Belgian telegram which I have read already. They invite any of our members to attend their meeting which takes place on June 20 and 21. Various functions have been arranged to which our members are cordially invited.

The meeting agreed that suitable replies should be sent.

Delegates from Abroad.

The SECRETARY: We have with us to-day from overseas:

Mr. Andrew Wilson (of Sydney, New South Wales).

Mr. S. Barker Johnson (of Colombo, Ceylon).

M. Reclus, of Paris, representing the Association Technique de l'Industrie du Gaz en France.

Dr. Keclik, of Czecho-Slovakia, would have been here, but he had promised previously to attend the meeting of the French gas engineers.

Mr. John Irminger (of Bergen) is here representing the Danish Association of Gas Engineers.

Herr Lempelius would have been present, but as he is Secretary of the German Association, he has to be at their meeting in Hamburg.

Mr. Hayman, of Antwerp, is representing our Institution at the meeting of the Association Technique.

Mr. Blackburn is here from Hong Kong.

From Italy we have Comm. Ing. Giuseppe Canova (of Turin). Another gentleman from Italy was invited, and

said he would be here—Ing. Dott. Ugo Dellacasa (of Turin), representing the Association of Italian Gas and Water Engineers. [He was introduced later.]

Mr. John Irminger represents also the Norwegian Gas Association, who are holding their meeting from Aug. 25 to 27 at Bergen. Any member of this Institution is heartily invited.

Then we have Mr. H. W. T. Pilbeam (of Santos, Brazil).

From Sweden there is Herr John Jacobson (of Kalmar), who has an address from the Swedish Gas Association. With Mr. Jacobson's permission, I will inform you of its contents. It says that the Swedish Gas-Works Association extend the most cordial greetings and wishes for the prosperity of The Institution of Gas Engineers, and express their expectation and conviction that the Royal Charter which was to have been received for this meeting may confer a great benefit upon the Institution and its members, and may actively further the aim for which we all work—the success of the gas industry. It is signed by the President.

Switzerland was to have been represented by M. H. Zollikofer (Secretary of the Swiss Gas and Water Association). Many members will remember that M. Zollikofer was present at our meeting when Mr. Ferguson Bell was President of the Institution, and that he helped us in connection with the first paper on waterless gasholders, We had the honour to be the first Institution to recognize the importance of that subject. He is not present on this occasion.

From the United States of America there is Prof. Jerome J. L. Morgan, M.Sc., Ph.D. (of the American Gas Association). He is Associate Professor of Chemical Engineering at Columbia University, City of New York.

Now we have, as the workpeople's representative on the National Joint Industrial Council for the Gas Industry (of which Sir David Milne-Watson is Chairman), Mr. Will Thorne, M.P. (the Vice-Chairman).

Another visitor from Brazil, representing the Rio de Janeiro Tramway, Light and Power Company, is Senor Victor Perdigao de Oliveira.

The PRESIDENT: I will now ask for responses to be made very briefly by Mr. Irminger, Mr. Pilbeam, Mr. Wilson, and Mr. Thorne.

Response on Behalf of Foreign Delegates.

Mr. JOHN IRMINGER (Bergen, Norway): I have great pleasure in thanking you, Mr. President and gentlemen, on behalf of the foreign delegates, for the kind welcome you have extended to us. It is a great pleasure to us to be present here at this meeting, in this ancient and noble city of Cardiff, because we know that the work done by the Institution is not only of value to the gas industry of this country, but it is of great value to the gas industry of all countries. If we abroad can do anything which may assist you in your efforts or add to the valuable work you are doing, we shall be very pleased to do it. Your members are always welcome to any information and assistance we may be able to give you. We thank you heartily for your kindness in inviting us.

Response on Behalf of British Overseas Delegates.

Mr. H. W. T. PILBEAM (Santos, Brazil): I might speak on behalf of my colleagues in South America. We feel, perhaps, that we are rather more passive than active members of the Institution; but we owe the Institution a great debt of gratitude for all the researches it carries out, and for all the information that we acquire, without actually assisting personally in the matter. My colleagues, I am sure, will join with me in thanking you most heartily for all the help you give us abroad.

Mr. ANDREW WILSON (Sydney, New South Wales): You will understand that it is with feelings of more than pleasure that I find myself, after an absence of twenty years, again in this country. I am the bearer of a message to this Institution from Australia. I have been charged by the President and members of the Australian Gas Institute—perhaps the youngest body of its kind in the British Empire—to convey to you their good wishes, and their hopes that this meeting will be even more successful than previous meetings, and that the Institution will continue to lead the world in gas matters with even more brilliance than it has done in the past. I am also charged with a personal message to you, Mr. President, from the President of the Australian body. He hopes that at the close of your term of office you will feel, as we all here will feel, that your labours have been worth while, and that you have helped to create a new standard for meetings of this character. In conclusion, I thank you for the opportunity of addressing you.

On Behalf of the Workers.

Mr. WILL THORNE, M.P. (Vice-Chairman, National Joint Industrial Council for the Gas Industry): I think you all recognize that I am not a gas engineer; but although not a gas engineer, I am a very old gas worker, for I started to carbonize coal at Birmingham in 1875. I should like, Mr. President, in the name of the British and Continental organized workers in the gas industry, to thank you very heartily for the honour you have conferred upon us by asking me to attend your opening gathering this morning; and, on my own behalf, to thank you for the hospitality you have extended to me during my brief stay in Cardiff. I use the word "Continental," because the 350,000 workers connected with my organization, whom I represent, are linked-up with the gas workers in very nearly all the countries that are represented upon this platform to-day. I am not in a position to know whether the method of working on the Continent is better than ours. I am not in a position to know whether they get more gas out of a ton of coal than we do; and I am not in a position to know whether their gas is any better than that made in this country. But when it has been distributed and is burned in the houses, I do not suppose anybody could tell the difference between that made on the Continent and that made in this country.

I happen to be the Vice-Chairman of what is known as the National Joint Industrial Council for the Gas Industry. That organization came into being in 1919; and from its very inception we have had only one Chairman, one Secretary, and one Vice-Chairman. Sir David Milne-Watson has been Chairman from the beginning; and there has never been any competition for the chair, because we recognize that in Sir David we have an excellent Chairman. He is a very broad-minded man, and a man of good temper. My friend and colleague, Mr. Arthur Hayday, who is M.P. for one of the Nottingham divisions, is the Secretary. I think all the gas engineers present this morning will recognize that during the whole time that the Joint Industrial Council has been operating we have had very little dispute in any of the gas-works throughout the length and breadth of the country. It has been the means of settling any little differences that there have been from time to time. It has had many difficult and complex questions to deal with; but they have all been settled in a very friendly way. I think I am justified in saying that the Joint Industrial Council is one of the most intelligent bodies there is in this country. [Laughter and applause.] At any rate, it is the most intelligent one from my point of view. It is an organization which has worked exceedingly cheaply. You will be surprised when I tell you that last year the only monetary call that was made on the two sides—the employers' and the workmen's sides—was £18 each, making a total of £36. My recollection is that the expenditure exceeded our income by about 10s. Out of the £36 there are not many directors' fees to be paid. I hope—and I am very pleased to say I believe—that all of us on the Joint Industrial Council will work in the same harmonious way in the future as we have in the past. I understand that there are about 1100 engineers representing gas undertakings, and I think a little over 400 of them represent the local authorities. I do not know whether they are all linked up with the Institution.

The PRESIDENT: They are.

Mr. THORNE: I am pleased to know they are; and I should like them to consider linking-up with the Joint Industrial Council: I see no reason why not. I realize that the decisions arrived at by the Council are invariably carried out by the gas undertakings in the different parts of the country. As all the gas undertakings, both company and municipal, are represented by your organization, I only wish I could say that all the workmen in your gas undertakings were members of the organization as well. I am hoping that the time will arrive when there will be perfect organization on both sides, because I am more than convinced that the better the organization we have, from the employers' and the workmen's points of view, the greater the possibility of settling all those different

problems that crop up from time to time. Please allow me to thank you again for the honour you have conferred upon me, and for the hospitality I have received during my brief stay here.

Telegram from the Lord Mayor of Leeds.

The PRESIDENT: I have just received a telegram from the Lord Mayor of Leeds, who says:

> This year my duties prevent me attending conference. May the meetings be a great success. Greetings to all friends.—GEORGE RATCLIFFE, Lord Mayor of Leeds.

Communication from Dr. C. Carpenter.

The SECRETARY: There is a letter from Dr. Carpenter, addressed to the President. It is as follows:

> South Metropolitan Gas Company,
> 709, Old Kent Road, S.E. 15,
> June 6, 1928.
>
> DEAR PRESIDENT,—I am back here to-day after six weeks' absence due to the return of the effects of a chill I contracted last December. My doctor tells me I must devote all the time I can to storing rather than using energy; and I regret that it will not be possible, therefore, to attend the meeting at Cardiff next week. Please believe me when I tell you I value more than I can say the kindness prompting your letter to me. I had hoped up to the last minute to be able to express that by an acceptance.
>
> You, too, I see, have been unwell; but I hope you have now completely recovered, and that there will be nothing to mar the complete success of the concluding function of your epoch-making Presidency.
>
> (Signed) CHARLES CARPENTER.

Further Letters of Regret.

The SECRETARY: We have a message from Mr. J. H. Canning, of Newport, who asks that we should convey to the Council and to the members his apologies for absence. He is confined to bed with a chill, and sincerely trusts that the annual meeting will be a great success. There is also a letter from Mr. William Rogerson, of Middleton (Hon. Secretary of the Manchester District Institution of Gas Engineers), regretting that he will not be able to attend this meeting. He is just recovering from a serious illness, and will have to take things rather quietly for a time. The next letter comes from Mr. D. H. Helps, of Reading, expressing his regrets for absence, and saying that he is sending his Chief Assistant to represent him. There is still another letter, from Mr. Fred West (Past-Chairman of the Society of British Gas Industries and an hon. member of our Institution), in which he sends greetings and expresses regret that, in consequence of his visit to Australia, he is not able to be present at the meeting.

Membership of the Worshipful Company of Plumbers.

The SECRETARY: The Council wish me to inform the members that we have received a communication from the Worshipful Company of Plumbers, of London, offering to the members of the Institution membership of that Company. Any members who desire particulars will obtain them on application to me. It confers a great honour, and also may lead to the Freedom of the City of London.

Confirmation of Minutes.

The PRESIDENT: I will now formally move that the minutes of the last Annual General Meeting be taken as read, and confirmed.

This was agreed to.

Appointment of Scrutineers.

The PRESIDENT: We now want two Scrutineers to examine the balloting lists for the election of officers and Council for the year 1928-29. Mr. J. E. Blundell (Carlisle) and Mr. Claude Diamond (Barrow-in-Furness) volunteer their services.

Their appointment was unanimously agreed to.

H. E. Jones "London" Gold Medal.

The PRESIDENT: The next item in our proceedings is to present the H. E. Jones "London" Gold Medal to Mr. Thomas Carmichael, of Portsmouth, for the paper which he read on "Modern Carbonizing Economics as Exemplified by Results and Working Costs at the Works of the Portsmouth Gas Company." When the matter was considered, I think I may say it was unanimously in our minds that Mr. Carmichael's paper was worthy of, and the one for, the gold medal. There is no question that it was one of the most valuable contributions that we have had of recent years. He gave us the truth. He set before us his troubles and his results; and I have very great pleasure, on your behalf, in asking him to come forward and receive the medal. [Applause.]

Mr. THOMAS CARMICHAEL: I appreciate very highly the honour that has been conferred upon me in awarding me this medal for the paper which last year I contributed to the proceedings of the Institution; and I thank you, sir, for the extremely kind words with which you have presented it. The subject of carbonizing is always an interesting one to the members; and I am happy in the knowledge that the figures and statistics given in my paper have been found to be of some use to them. In connection with this matter, I should like to express my indebtedness to my Chairman, Mr. Lapthorne, to Mr. Doig Gibb, and their co-Directors, for their generous permission in allowing me to use the actual working costs and other figures relating to our Company. I naturally am very

THOMAS CARMICHAEL, M.I.Mech.E.
Awarded the H. E. Jones "London" Gold Medal.

gratified indeed at this token of your approval; and I thank you, sir, for your remarks, and those present for their cordial reception.

The Diplomas.

The PRESIDENT: I now have to present the diplomas to the successful candidates in the Institution examination of April, 1928. They are as follows:

First Class, with Distinction.

Mr. John Grayston, Hinckley.
Mr. Roy Summerson, Luton.

First Class.

Mr. Frank C. Sylvester, West Bromwich.

Second Class.

Mr. James L. Hyslop, Belfast.
Mr. W. I. Ineson, Bradford.
Mr. Harold B. Kendrick, Carlisle.
Mr. Egbert Harold Winch, Cambridge.

There is just one thing I should like to say regarding the successful candidates in the diploma examination who are receiving these certificates, and that is to assure you that they have won them by sheer merit. The diploma ex-

J. Grayston.

F. C. Sylvester.

R. Summerson.

J. L. Hyslop.

H. B. Kendrick.

SOME OF THE 1928 DIPLOMÉS.

amination is no light one. You know the members of the Examination Board, of which I have the honour to be Chairman. They look after your interests; and before the diploma is given, they see that a man knows his subject well. We congratulate the young men who have got them to-day, and hope to see their names in years to come high up in the records of this Institution. ["Hear, hear."]

Election of Temporary Honorary Members.

The PRESIDENT: I have now pleasure in moving: "That the respective Presidents of the National Gas Associations of the following countries be, and that they are hereby, elected honorary members of the Institution of Gas Engineers for the respective terms of their office as such: Australia, Belgium, Canada, Czecho-Slovakia, Denmark, France, Germany, Italy, Norway, Sweden, Switzerland, and the United States of America."

This was agreed to.

The President's Address.

The PRESIDENT then proceeded to deliver his address; and at its conclusion,

Mr. A. E. BROADBERRY (London) said: In the unavoidable absence of Sir David Milne-Watson, who was to have done so, I have had the honour of being asked to propose a hearty vote of thanks to our President for the most instructive and interesting address that he has just delivered to us. I am sure I am expressing your views when I say that it has been very inspiring. It is constructed in the most dignified and comprehensive way; and the arguments put forward are extremely sound. Our President is a true believer in the future of the gas industry. We all agree with him in this; and we thank him for having put the matter so lucidly forward in his address. What he has had to say has been expressed in so convincing a manner that I am sure he is not only preaching to the converted here, but the fame of the address will spread abroad and do the industry a great deal of good. I have great pleasure in moving that our best thanks be given him.

Mr. THOMAS GLOVER (Norwich): I have much pleasure in seconding this vote of thanks to our President for the very fine and inspiring address he has given us this morning. The address has been delivered in his own city—a city of generous spaces, and noble buildings, and of great national spirit. We thank him for inviting us to Cardiff, and for the able address which he has given us, and which will inspire us in the coming year. I am delighted to second the vote of thanks.

The vote was then put to the meeting, and passed with acclamation.

The PRESIDENT: I thank Mr. Broadberry and Mr. Glover for their kind remarks on my Presidential Address, and you, gentlemen, for the way in which you have received them. It has been a very great pleasure to me to write the address; and while I felt in the first place that you might have expected me to deal with engineering science as applied to our industry, what governed the drafting of my address this year was the fact that we had come to a change in the road. I am referring to the facts that we have altered the rules of the Institution and that we have applied for a Royal Charter. All this made me think it was time that we took stock of what we have accomplished, and of what may be the position of the industry in the future. That is what has been in my mind

W. E. PRICE, Assoc.M.Inst.C.E.
Hon. Secretary of the Institution.

when writing this address. I thank you all for the way in which you have received it.

Welsh National War Memorial.

At this point in the proceedings, there was an adjournment until the afternoon, so as to permit the members to proceed to Cathays Park to witness the unveiling ceremony of the striking Welsh National War Memorial by H.R.H. the Prince of Wales, who is an Honorary Life Member of the Institution. There had been displayed at the front of the platform during the morning the wreath of laurel leaves, pink carnations, and choice white flowers, with mauve ribbons bearing the words " Homage from the President and Members of The Institution of Gas Engineers," which was subsequently placed upon the Memorial. In connection with this unveiling ceremony, the ladies accompanying members to the Cardiff meeting were thoughtfully provided with seating accommodation. It was a happy circumstance that the Institution should have been able to take a part in proceedings which made the day such a memorable one in the history of Cardiff.

New Morriston Works at Swansea.

Mr. W. H. Johns, of Swansea, opened the afternoon session on Tuesday, by presenting his paper on " The New Morriston Works of the Swansea Gas Light Company," which he illustrated by a series of some sixty lantern slides. In introducing his paper, he said : I should like to offer an apology for bringing this matter up a second time. Inasmuch as we have now completed the new works, however, and have incorporated a water gas plant with self-clinkering grate—the first in South Wales —I feel that perhaps you will find the matter interesting.

Annual Report and Accounts.

[See " JOURNAL " for June 6, p. 660]

The PRESIDENT : I think every member has had a copy of the report of the Council for the year 1927-28, and of the accounts for the year ended Dec. 31, 1927; and to facilitate business, I formally move their adoption.

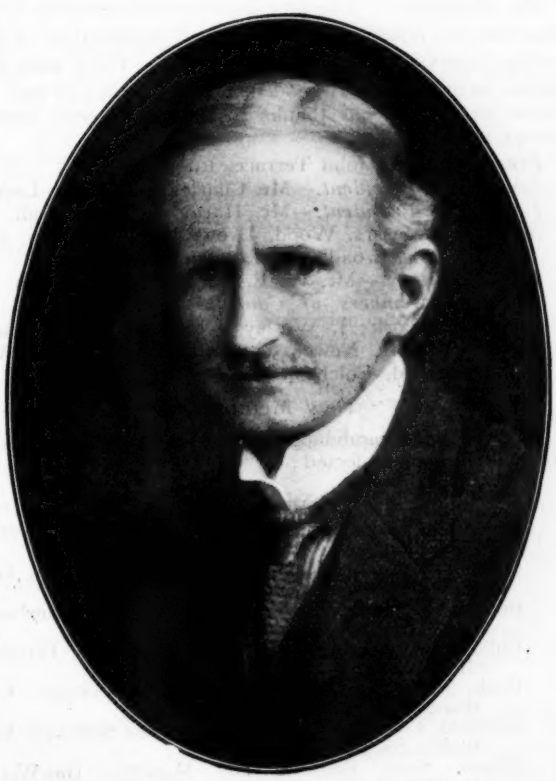
Mr. J. FERGUSON BELL (Derby) : I shall be happy to second that.

The PRESIDENT : If there are no questions, I will put the resolution to the meeting.

Carried unanimously.

Nineteenth and Twentieth Reports of the Gas Investigation Committee.

Prof. J. W. COBB, introducing the nineteenth and twentieth reports of the Gas Investigation Committee, said : " I am afraid I must begin by saying something I am extremely sorry to say, and which I am sure you will be extremely sorry to hear. It is with the greatest possible regret that the Gas Research Sub-Committee has to report that the end of its working year brought the resignation of its Chairman, Prof. Smithells. I shall make no attempt here to enumerate the invaluable services which Prof. Smithells has rendered to the Committee, to the Institution, and to the industry. When official co-operation commenced between The Institution of Gas Engineers and the University of Leeds, by the formation of a joint Committee for the purpose of research, the choice of Prof. Smithells as its first Chairman was inevitable. He had done so much of the work that led up to the formation of the Committee, and made its effective constitution and working possible. Since that time he has occupied the chair, and he has brought to bear upon the work of the Committee throughout an enthusiasm, a competence, and a degree of interest which have gone far to account for the considerable degree of success which we may claim, I think, for the work of that Committee. The work has been developed in a number of directions. Prof. Smithells now believes that a stage has been reached at which he may very well be relieved of the stewardship which he has carried through so successfully, and so much to the credit of the Institution and of the University of Leeds. The one thing that I know consoles him in bringing that part of his work to a close is that he knows that the Chairmanship of the Committee has passed into entirely competent hands. Mr. Thomas Hardie, of the Gas Light and Coke Company, has succeeded him as Chairman. [Applause.] Another thing which I am sure you will be pleased to know is that, by the unanimous wish of the Committee, Prof. Smithells has consented to retain his membership, although he has resigned the Chairmanship; and he will continue, therefore, to give us the benefit of his unique experience in these matters. There has been another change in the constitution of the Joint Committee during the year; Mr. C. F. Botley having taken the place of Mr. Charles Wood, who, after a long period of membership, has retired from professional work on



Prof. JOHN W. COBB, C.B.E.

account of ill-health. Mr. Wood rendered constant, ungrudging, and effective service, for which the Committee are very grateful.

[Prof. Cobb then briefly referred to the two reports.]

The PRESIDENT: I should like to pay a tribute from the Chair to Prof. Smithells on his retirement from the Chairmanship of the Gas Research Sub-Committee. I know that the Sub-Committees and other Committees have placed on record what he has done, and how much the industry appreciates it; and I should like to add my meed of praise, and to say how much the Institution values the work he has done for it. We are very glad to hear that he will remain on the Committee, and we are somewhat relieved of anxiety to know that Mr. Thomas Hardie will follow him.

Mr. J. W. WOOD presented the nineteenth report; and Dr. A. PARKER the twentieth report.

Benevolent Fund Meeting.

Before the Institution resumed its meeting on Wednesday morning, there was held the annual meeting of the Benevolent Fund. The reports of the meeting and of the Committee of Management will be found elsewhere in this issue.

Further Greetings.

The PRESIDENT, on opening the session of the Institution, said: I have two telegrams to read to you. The first is:

> Fraternal greetings to Institution of Gas Engineers during its annual meeting, from American Gas Association. Best wishes for very successful meeting. Oscar H. Fogg, President and Managing Director.

The other is one in which I take very great personal pride, because it comes from a former member of my staff, Mr. H. C. Carder, who is now at Rio de Janeiro. He has sent one of his staff, Senor V. P. Oliveira, to be present at these meetings. Mr. Carder wires:

> Greetings and best wishes for very successful meeting this week.—Carder.

If you will leave the matter to us, we will have suitable replies despatched.

List of New Officers.

The PRESIDENT: The first business this morning is to announce the result of the Scrutineers' examination of the voting papers for the election of officers. There were 629 papers in order, and 21 spoiled, making a total of 650. I desire to express our thanks to the Scrutineers, whose report is as follows:

President.—Mr. John Terrace, London.
Senior Vice-President.—Mr. Charles S. Shapley, Leeds.
Junior Vice-President.—Mr. Harold E. Copp, Hull.
Auditors.—Messrs. Wood, Drew, & Co., London, and Mr. A. E. Broadberry, London.
Hon. Secretary.—Mr. W. E. Price, West Chobham.
Ordinary Members of Council.—Messrs. Harold E. Bloor, York; J. Wesley Whimster, Bath; Frank P. Tarratt, Newcastle-upon-Tyne; and W. W. Townsend, Colchester.

New Members.

The following candidates for membership and associate membership were elected:

MEMBERS.

Bell, John Hogg, Engineer and Manager, Gas-Works, Portrush.
Bowness, Frank Graham, Engineer and Manager, Gas-Works, Maryport, Cumberland.
Buckley, William, Manager, Droylsden Works, Manchester Corporation Gas Department.
Childs, George Edward, Manager, Gas-Works, Ferndale, Glam.
Cook, Jasper, Engineer, Manager, and Secretary, Gas-Works, Fenny Stratford.
Delafield, Frederick Wright, Manager and Secretary, Gas-Works, Shepton Mallet, Som.
Dickie, Sam, Engineer and Manager, Gas-Works, Dumfries.
Edwards, Alfred, Works Chemist, Beckton Station of the Gas Light and Coke Company.
Farquhar, Lawrence, Engineer and Manager, Corporation Gas Department, Peebles.
Garrard, William James Collins, Assistant to Engineer and Manager, Gas-Works, Ipswich.
Hardy, John Henry, Chief Assistant Engineer, Corporation Gas Department, Coventry.
Jones, John Prosser, General Manager and Secretary, Rhymney and Aber Gas Company.
Lupton, H. P., B.Sc. (Institution's 1st Class Diplomé in Gas Engineering, 1927), Chief Chemist, Liverpool Gas Company.
MacDougall, Peter, Engineer and Manager, Gas-Works, Cinderford.
O'Connor, David, Engineer and Manager, Gas-Works, Maryborough, Ireland.
Poulson, Joseph, Engineer and General Manager, Gas Department, Oldbury U.D.C.
Seagrave, Thomas Alfred, Manager and Secretary, Gas-Works, Corbridge-on-Tyne.
Stones, Edward Edison, Assistant General Manager, Corporation Gas Department, Glasgow.
Thirsk, James W., Engineer and Manager, Gas and Water Department, Beverley.
Thomas, William Henry, Engineer and Manager, Gas-Works, Alcester.
Waddell, Robert Bruce, Engineer and Manager, Gas-Works, Polmont.
White, Osman, Gas Manager and Water Superintendent, Haworth U.D.C., near Keighley.
White, Tom Edmund, Manager, Gas-Works, Saltash.

ASSOCIATE MEMBERS.

Abbott, John Gerald, Assistant Manager, Gas-Works, Windsor.
Appleyard, Norman Gaunt, Assistant Manager, New Wortley Works of the City of Leeds Gas Department.
Armour, John, Chief Chemist and Assistant to Manager, Corporation Gas Department, Paisley.
Blundstone, William Hugh, Technical Assistant, Corporation Gas Department, Dewsbury.
Bointon, Ernest, Chemist and Works Assistant, Gas-Works, Scarborough.
Booth, Francis Noel, Chief Draughtsman, Corporation Gas Department, Rochdale.
Bounds, Thomas, Sole Assistant to Engineer, Forest Gas-Works, Brussels.
Boyns, Stuart Harley Wallis, Assistant Engineer, Harrow Station of the Gas Light and Coke Company.
Broughton, Geoffrey Walton, Assistant Engineer and Manager, Gas-Works, Haslingden, Lancs.
Buttery, George Gilbert, Technical Assistant in Retort House, Corporation Gas Department, Birmingham.
Coburn, George Scott, Assistant Engineer and Manager, Winchester Water and Gas Company.
Copp, Arthur Douglas Lewis, Assistant Engineer and Manager, Corporation Gas Department, Macclesfield.
Davies, Charles Swainson, Deputy Gas Engineer and Manager, Corporation Gas Department, Chesterfield.
Dieterichs, William, Special Representative in Charge of Industrial Appliances, Workshops, and Showroom, Gas Light and Coke Company.
Dunbar, Edwin, Assistant Engineer, Gas-Works, Southampton.
Farquhar, Arthur Watt, Technical Assistant, Gas-Works, Leven.
Gavin, Robert James, Chief Technical Assistant, Gas Department, Kirkcaldy.
Goodwin, Frank, Manager, Kowloon Gas-Works, Hong Kong.
Grayston, John, Assistant Engineer and Manager, Gas-Works, Hinckley.
Greig, Harold, B.Sc. (Lond.), Acting Superintendent, Gas-Works, Rio de Janeiro.
Gunston, George Cecil, Assistant Distribution Superintendent, Bristol Gas Company.
Hart, Cyril Alfred, Superintendent of Meter Shops, South Metropolitan Gas Company.
Heathcote, William, Distribution Superintendent, Corporation Gas Department, Halifax.
Henderson, John Boyle, Distribution Superintendent (Wallsend area), Newcastle-on-Tyne and Gateshead Gas Company.
Hepworth, James Alexander, B.Sc., A Senior Assistant Engineer, Beckton Station of the Gas Light and Coke Company.
Hodgson, Albert, General Superintendent, Gas and Water Departments, Newton-in-Makerfield U.D.C.
Holden, Arthur Stanley, Technical Assistant, South Metropolitan Gas Company.
Ineson, Wilfred Illingworth, Chief Chemist, Corporation Gas Department, Bradford.
Jackson, Frederic James, Assistant Works Superintendent, Neepsend Station, Sheffield Gas Company.

Jones, Albert, Superintendent of Mains, Bristol Gas Company.
Kaye, Joseph William, Superintendent, Corporation Gas Department, Pontefract.
Keillor, Ronald Dempster, Chief Assistant Engineer and Manager, Greenock Corporation Gas Department.
Kennington, John, Distribution Superintendent, Great Grimsby Gas Company.
Kinnear, George Rae, Superintendent, Gas-Works, Birkenhead.
McBain, James, Works Superintendent, Corporation Gas Department, Halifax.
MacNaughton, William, Assistant Works Superintendent, Gas-Works, Wolverhampton.
Marsh, Richard Gregory, Fittings Engineer, City of Birmingham Gas Department.
Masters, Alfred, Assistant Mains Superintendent, South Metropolitan Gas Company.
Maycock, Harry, Assistant Engineer and Manager, Gas-Works, Sittingbourne.
Murray, Charles Henry, Assistant Works Engineer, Brentford Station of the Gas Light and Coke Company.
Porter, John Richard, Works Manager, South Shields and Jarrow Gas-Works.
Pye, Harold Victor, Technical Assistant, Gas-Works, Chester.
Pykett, Frederick Albert Clarence, Distribution Engineer, Corporation Gas Department, Coventry.
Ratcliffe, Henry Cecil, Chemist and Assistant, Gas-Works, Hornsey.
Robb, David, Engineering Assistant, Gas-Works, Uddingston.
Roxburgh, Allan Burgess, Chief of Sales of Gas Department, Designer of Apparatus, Furnaces, &c., Newcastle-on-Tyne and Gateshead Gas Company. (Examiner in Gas Supply under Institution's Education Scheme.)
Sanders, Frederick Arthur, Engineers' Technical Assistant, South Metropolitan Gas Company.
Smalley, Arthur, Assistant Manager, Gas-Works, Castleford.
Smith, Charles Edward, Assistant Gas Engineer and Manager, Aberdeen.
Thomas, Leonard Howard, Works Superintendent, Corporation Gas Department, Smethwick.
Thompson, William, Jun., Assistant Manager, Gas-Works, Musselburgh.
Tunmore, William, Works Manager, Gas-Works, Bishop Auckland.
Tyndall, Frederick, Technical Assistant and Chemist, Gas-Works, Deal.
Wallis, Ernest Leonard, Chemist in charge of all gas making and purifying plant and laboratory, Gas-Works, Dudley.
Weldon, Laurence Matthew, Distribution Superintendent, Gas-Works, West Hartlepool.
Williams, Frederick Booth, Works Manager, Hoylake U.D.C. Gas Department.
Willsmere, Albert Charles, Manager, Gas-Works, Fleetwood.
Wilson, George Gerard, Engineer and General Manager, Carbonization, By-Products Works, and Gas Distribution, Whitwood Chemical Company.

ASSOCIATE.

Ridley, Thomas Percy, Secretary and Commercial Manager, Newcastle-on-Tyne and Gateshead Gas Company.

Gasholder Construction and Deterioration Committee.

The PRESIDENT: I will now call upon Mr. Doig Gibb to give us his report of the Gasholder Construction and Deterioration Committee.

Mr. W. DOIG GIBB: Some of my friends have told me that they were expecting an interesting discussion upon the construction and deterioration of gasholders; but subject to your ruling, Sir, as President, it seems to me that to-day I can only give you the formal report of the Committee of which I am Chairman. As Chairman, one has responsibilities; and these are such that I do not propose to give the report verbally, as is announced in the programme, but to read it.

THE REPORT.

This Committee is a very necessary one, and its formation was probably hastened by the recent gasholder accidents at Pittsburgh, Truro, and Manchester. As you are aware, a public inquiry was ordered to be held in connection with the last named. At the opening session of the inquiry on Feb. 2, Mr. Shapley, our Junior Vice-President, represented the Institution. The Council, at their meeting on Feb. 13, appointed a Committee consisting of the President, Hon. Secretary, Junior Vice-President, and Messrs. Botley, Fottrell, and Moon to deal with questions arising from the Ministry of Health inquiry; and at the adjourned inquiry the Committee and the Institution were represented by Messrs. Shapley, Wilkinson, and W. J. Smith. What these gentlemen did at the inquiry has been recorded in the Technical Journals; and Mr. Shapley has reported their action to the Gasholder Committee and to the Council. It was understood by the Council that I should join the Committee as soon as possible. I was able to do so at the first meeting of the Committee on March 12, and the Committee did me the honour of appointing me their Chairman.

We have not yet started serious work, as it was felt that definite action was premature until after the Departmental report on the Manchester accident had been made public. It is not that the Committee's future programme will be dominated by such a report—on the contrary, the report will be only one of many factors which will have to be considered. The report is not yet published. I can therefore only state now that the work of the Committee is in the future; and I trust that, at the next annual meeting, I, or some other Chairman, may be able to report that much useful work has been done.

As the President has said in his admirable address, it will be the duty of the Committee "to keep in close touch with all questions affecting the structure, care, and upkeep of our storage plants." This broad charter will mean hard, responsible, and tactful work; and the Committee rely upon the members to give them such private information as they may desire to have.

The PRESIDENT: We are very much indebted to Mr. Doig Gibb for his report. As a member of that Committee, I think it is premature at the present time to open any discussion. We were first concerned with the Manchester business; and we have gone into that. We have also been considering in which direction we are to work. As Mr. Doig Gibb has said, the matter requires very tactful handling; and I would suggest that at this juncture we cannot very well discuss the question. We have not yet properly started on it. If, however, members have any suggestions or points they would like to put forward, and will send them to Mr. Doig Gibb or to the Institution, we shall be very glad indeed to have such outside help. No one knows better than Mr. Doig Gibb himself what a difficult question this is to deal with. I will formally move the adoption of the report, and leave the matter there for the time being.

Mr. J. TERRACE seconded the motion, which was agreed to.

High-Pressure Distribution.

The next item was a paper by Mr. Stephen Lacey, Distribution Engineer to the Gas Light and Coke Company, on "The Economic Aspects of High-Pressure Gas Distribution."

Distribution System at Tottenham.

This was followed by a contribution by Mr. H. C. Smith, Chief Engineer to the Tottenham Light, Heat, and Power Company, entitled "Some Recent Alterations and Extensions in the Distribution System at Tottenham."

Suggestion for a Standing Committee on Distribution.

The PRESIDENT, at the close of the discussion on Mr. Smith's paper, said: I have had a note in the following terms from Dr. E. W. Smith: "Would you welcome a suggestion that the Council should set up a small Standing Committee on Distribution, to keep the Institution *au fait* with the subject, and report fully on matters concerning naphthalene, gas drying, mains, &c.?" In reply to that, I can only say that I will pass the suggestion on to the Council.

Second Report of the Effluents Research Committee.

As Chairman, Mr. CHARLES F. BOTLEY, of Hastings, submitted the second report of the Effluents Research Committee.

Gas for Therapeutical Purposes.

Dr. E. W. SMITH presented the report of the Gas for Therapeutical Purposes Committee.

Wrought-Iron Tubing Committee.

In the unavoidable absence of Mr. Albert Stokes (Joint Manager, South Metropolitan Gas Company), who is Chairman of the Wrought-Iron Tubing Committee, Mr. H. Hollings (Chief Gas Chemist to the Gas Light and Coke Company) presented this report (as appearing in the Council's annual report).

Mr. C. F. BOTLEY, who proposed the adoption of the report, said: The Committee have now widened their work, and are dealing with the question of corrosion.

The PRESIDENT: Have you anything to report as to that?

Mr. BOTLEY: The position to-day is that we have finished the specification with regard to wrought-iron tubing. The Council then asked us to take up the question of corrosion, and that is being proceeded with.

Mr. F. P. TARRATT, who seconded the adoption of the report, said: The Committee are carrying out investigations with regard to corrosion; but we are not in a position to report any particular advance at the moment. The results will be reported in due time.

The PRESIDENT: We shall await with interest a full report by the Committee on that question.

The report submitted was adopted.

Education Committee.

In the unavoidable absence of Mr. F. W. Goodenough (Chairman), the report of the Gas Education Committee was brought forward by Mr. Terrace.

Livesey Professorship.

Prof. J. W. COBB (Livesey Professor): This is a new item on the Institution's programme; and I rather welcome it, because I might at any time desire the opportunity of saying something rather special on the subject of the Livesey Professorship. A full report is due periodically; and this statement (in the Council's annual report) is really quite a brief summary which is presented to the Council of the Institution yearly. The only thing to which I might call your attention is a sentence at the end. There has been a growing conviction, I believe, for many years in the gas industry, and in all the industries which are concerned with the utilization of fuel, that their higher technical direction is going to demand the best possible scientific training which a University can give. The sentence I refer to states that the demand by the gas industry and by the fuel industries generally for men trained in the department over which the Livesey Professor presides has been very insistent and steady throughout the year; and the position now is that no student who has taken his Degree or Diploma at the University is without a post. [Applause.] I think I can leave it at that.

Dr. E. W. SMITH, proposing the adoption of the report, said: "I think the members of the Institution should appreciate that, while the scheme of education for the Diploma is supremely important to what one might call the rank-and-file of the industry, it is vitally necessary that there should be just as much care given to the training of those who are going to lead in research work and in the higher scientific side of the industry as of those on the normal or practical side. I am quite certain that those who are watching the development of other industries—such as the chemical industry—will realize that if the gas industry is to keep its place ten, twenty, and thirty years hence, it is necessary that in those higher branches more elaborate training should be developed, in the way that it is developed at Leeds; and the more encouragement we can give engineers who have promising sons to send them to Leeds, or to any other University where they will get as good a training—and I know of none—the better it will be. There is just as much depending upon the training of those scientific workers as upon the training of what I call, for want of a better phrase, the rank-and-file.

Mr. R. ROBERTSON (Bristol) seconded the adoption of the report.

The PRESIDENT: I am in perfect agreement with Prof. Cobb and Dr. Smith. I should like to add that though a man holds the B.Sc. Degree of Leeds University, and the Committee recognize that fact, it must be remembered that he has to take the oral examination and the thesis, and pass before he can receive the Diploma. We find, from our experience, that this is a very wise procedure.

The report was adopted.

Gas Research Fellowship Report.

Thursday morning's session opened with the presentation by Prof. Cobb of the report of the Institution Gas Research Fellow, Mr. F. J. Dent, who followed with a summary of its contents.

Chemistry in Gas Making.

Mr. H. HOLLINGS, Chief Gas Chemist to the Gas Light and Coke Company, then read a paper on "Some Applications of Chemistry in Gas Making."

Gas Supply East of Suez.

The PRESIDENT: I have consulted the members of the Council who are round me in regard to the next paper, which is by Mr. S. Barker Johnson, of Colombo, on "Gas Supply East of Suez." We feel that, as our time is so limited, we must take this paper as read. I do not think there are any points in it which are controversial. We are very happy indeed to have it; and I think it will be useful in the "Transactions" as guidance for any one who thinks of going abroad. It has been a pleasant experience to me as President this year to meet so many overseas engineers. I have had a long conversation with Mr. Andrew Wilson, of Sydney; and I find that we at home do not know the different conditions under which our brother engineers have to work abroad. For that reason I feel very grateful for Mr. Johnson's paper; but in the circumstances I am sure he will appreciate the necessity for taking it as read, so that we may finish our programme.

Refractory Materials Committee Report.

The report of the Refractory Materials Joint Research Committee was presented by the Chairman, Mr. J. P. Leather.

Coal Analysis and Sampling Committee.

Mr. W. J. Smith, of Bolton, submitted the interim report of the Coal Analysis and Sampling Committee of the British Engineering Standards Association.

International Commission on Illumination.

The report of the International Commission on Illumination, which met at Bellagio, was presented by Mr. Robert Watson, of Doncaster, Delegate of the Institution.

National Illumination Committee Report.

This was followed by the report of the National Illumination Committee of Great Britain, which was introduced by Mr. Fras. C. Briggs, of Dudley, one of the five representatives of the Institution on this Committee.

Presidential Certificate.

Mr. J. TERRACE: The next item on the programme is to me a very pleasurable one. I feel it a great privilege to have the duty of handing over to the President towards the close of his year of office a tangible token of his services in that position. But I would like to convey to him that the presentation of the Presidential Certificate, which we trust he will always treasure, is a very small part. Mr. Madden's work among us here is his monument. On behalf of the Council, I tender him sincere thanks for the kindly way in which he has conducted the proceedings during the year. The general body of members see only

AN EXPLANATION BY THE PRESIDENT AT THE GRANGETOWN WORKS.

a very small part of the work of the Institution. The work of the Council year by year becomes more and more onerous, and depends to an ever-increasing extent upon the tact, courtesy, and help of the President. Mr. Madden possesses in no small degree the qualities I have named; and, with his great help, it has been very pleasant indeed to carry on the work of the Institution during his year of office. But as nearly every one will be remembered by some particular thing that has taken place during his year, so it falls to the lot of Mr. Madden to go down to posterity as having been your President during the year in which it became possible for the Institution to alter its rules and to apply for a Royal Charter. It is no new thing, and the President knows and acknowledges the work that has been done by the pioneers in bringing the matter forward; but I should be lacking in my duty if I did not place on record what all of us on the Council feel—that it is very largely due to the personality of our President that this matter was brought to fruition during his year of office. It is a very important milestone in the history of the Institution.

The Council wish the President to accept their thanks for his unfailing kindness during the year which has just passed; and I am sure that the members generally would desire me to voice on their behalf the great respect and admiration—I might almost say love—which we all have for our President. It may seem hardly necessary to say it, but I wish to place it on record, that during our visit to Cardiff, which will live long as a very pleasant memory with all of us, every one has much appreciated the wonderful arrangements which have been made for us. We are very proud, Sir, to come and visit you in your own home, to witness the esteem in which you are held in your own city, and to bear testimony here to your sterling work as the President of The Institution of Gas Engineers. I am afraid I have been trespassing a little on the next item, which is a vote of thanks; but I felt that, in handing this certificate to Mr. Madden, I could not fail to take advantage of the opportunity of telling him in some very inadequate words how much we appreciate him. [Applause.]

The President's Acknowledgment.

The PRESIDENT: I think this must be about the most difficult moment in my life. I thank Mr. Terrace for the kind words he has said, and you gentlemen for the way in which you have received them. Mr. Terrace has referred to what I have done during my Presidential year. I have always loved the gas industry, and whatever work you have passed your appreciation upon has not been hard labour to me, but a labour of love. When one gets so intensely interested in these matters as I do, one forgets any hard work that may be involved. Until I took the chair for the first time, I did not realize how many devoted friends I had in the gas industry. All have rallied round and done their best to help me to make it a successful year. Mr. Terrace has been always at my side to assist me. And so it must be. With the ever-increasing work, the Senior Vice-President must be at hand to do some of it for the President. There is one thing that I should like here to acknowledge publicly. I unfortunately had an illness a couple of months ago; and the first day the doctor allowed me to get up there was brought to me a huge box of very choice fruits, with a card stating that it was from the Council of the Institution, who wished me a speedy recovery. I was deeply touched by this kindness, which went right to my heart. If during my year of office we have amended our rules and gone forward for a Royal Charter, and if we have made any advance, then we have merited the trust that you have reposed in us. I am most grateful for the loyal support that every one has given me. Mr. Terrace has given me the certificate. I have now to hand him the President's keys.

Place of Next Meeting.

Mr. TERRACE: We have now to consider the place of meeting next year. I take it you will accede to my request that it should be in London. ["Hear, hear."]

Votes of Thanks.

Mr. TERRACE: We start now on the votes of thanks, and the first is to the Lord Mayor and Lady Mayoress. I consulted the President as to the desirability of sending a communication as soon as possible to the Lord Mayor to thank him for his great kindness to us in opening the meetings and in entertaining us at the City Hall; and I think I cannot do better than to read the letter which it is proposed should be sent by me as President-Elect:—

> My Lord Mayor,—It is the desire of the members of The Institution of Gas Engineers that their thanks

to you for your great kindness, hospitality, and courtesy during their visit should be conveyed to you as soon as possible after the memorable gathering at the City Hall last evening. They greatly appreciate your kindness in being present to welcome them at their opening session, especially as it must have been difficult to find time on such a busy day in your civic life.

Their visit to Cardiff will long be remembered by them, and they feel that words cannot adequately express their gratitude to you. Many of the ladies who were present last evening have asked me to express to you their hearty thanks for the good time which you provided for them, and the members wish to join most sincerely in this.

At the meeting this morning, the following resolution was passed: "That the best thanks of The Institution of Gas Engineers be tendered to the Lord Mayor and Lady Mayoress of Cardiff for their hospitality during the meetings, and especially for the memorable gathering at the City Hall on Wednesday evening."

I have the honour to be, My Lord Mayor,
Yours very truly,
JOHN TERRACE, President-Elect.

Mr. C. S. SHAPLEY: We are very much indebted to the Lord Mayor and to the city for the way in which we have been entertained. It reflects the respect in which the President and his Directors are held. I have the greatest possible pleasure in seconding the proposal that this letter be sent to the Lord Mayor.

The PRESIDENT: I, too, should like to express my appreciation of all that the Lord Mayor and Lady Mayoress have done for us. We had a wonderful evening at the City Hall, and I feel sure that every one enjoyed it. I have taken the opportunity of writing a personal letter to the Lord Mayor, who is a particularly good friend of mine. I would like you to give your assent to the sending of the letter which has been read by Mr. Terrace. [Applause.]

Chairman and Directors of the Cardiff Gas Company.

Mr. J. H. CANNING (Newport): I have been asked to propose a vote of thanks to the Chairman and Directors of the Cardiff Gas Light and Coke Company for so kindly according permission to the members and their ladies to visit their gas-works and showrooms, and for the hospitality shown to them during the meeting. I need hardly say that it is a great pleasure to me to propose this resolution, which is so well deserved. As a close neighbour, perhaps I may be able to say in justice to Mr. Madden's Directors something more than one who comes from a distance could; and what I wish to say is that the hospitality shown on the present occasion is not an isolated instance, but is part of the continuous and considered policy of the Cardiff Gas Company. Ever since the foundation of the District Institution, over twenty-five years ago, the Cardiff Gas Company have extended continuous hospitality and help, not only to that body, but to the Junior Association, to the Federation of Gas Employers, to the National Gas Council, and to every other organization working on behalf of the gas industry. They have followed a consistent policy of helping every association or body which in their opinion is assisting the gas industry. On the present occasion this policy has been followed out to the utmost extent that lay in their power; and we feel that this is largely due to the very high esteem in which his Directors rightly hold our President. Each one of us in his official capacity represents to his committee-men or board of directors this Institution; and it is in this way that they judge the Institution. Thus it is hardly necessary to stress the point that the Cardiff Gas Company cannot but have the highest possible opinion of the Institution; and this has resulted in the hospitality and support which have been extended to us. I should like, before concluding, to say that, in my opinion, we cannot pass this vote of thanks without coupling with it the whole of the staff of the Cardiff Gas Company. ["Hear, hear.] It would be impossible to name all those who have helped, as I should simply be giving the roll of the Directors and employees; but I should like to say that our thanks are specially due to Mr. R. J. Auckland and Mr. Wilfrid Jones for the labour they have unstintingly put in in connection with this gathering.

Mr. J. FERGUSON BELL: It affords me the greatest pleasure to second this vote. The visit to Cardiff will be long remembered, and we owe a deep debt of gratitude to the Chairman and Directors of the Gas Company. The number of fine buildings in the city proves that the people of Cardiff have had vision, and I venture to say that the Directors and others responsible for the Gas Company have also had vision. Much of the success of a memorable meeting has been due to what they have done for us. [Applause.]

Reception Committee.

Mr. ANDREW WILSON (Sydney): As a visitor to your delightful country, I have been particularly struck with the wonderful amount of work done by your Reception Committee. It is indicative of the spirit which still lives in the old country, and which I am delighted again to experience. I am therefore glad of the opportunity of moving a vote of thanks to the Reception Committee and Ladies' Reception Sub-Committee for their ready assistance, so courteously rendered, in making arrangements for welcoming the members and their ladies attending the meeting. It has been of considerable profit to me to be here; and I am going back to Australia primed with something for which I specially came over. My visit has been a success from the very moment of this meeting.

Mr. SAMUEL GLOVER: I have very great pleasure in seconding the resolution.

Mr. OCTAVIUS THOMAS (who was cordially received) said, in reply: Mr. Madden blames me for his being President, so the least I could do was my best for him. I thank you on behalf of the Reception Committee for your vote. We have only done our duty.

President and Council.

Mr. RALPH HALKETT (Sheffield): I rise to propose a vote of thanks to the President and Council of the Institution for their services during the year 1927-28. Mr. Madden is a gentleman who is held by us all in the warmest esteem; and when we asked him to become our President, we had every confidence that he would successfully fill his high position. During the year he has had many duties to perform; and he has carried them out with great credit, not only to the Institution, but to himself. I had hoped to have the opportunity of congratulating him upon the obtaining of the Royal Charter; but doubtless that will come very soon, and it will be due in no small measure to the work put in by our President, whose name will always be associated with it. We are also greatly indebted to Mr. Madden for his Presidential Address, from which, on careful study, we shall derive further pleasure and profit. To Mrs. Madden, too, we must extend our warmest thanks for the great interest she has taken in the welfare of the ladies. Then our thanks are due to the members of the Council for the arduous work they have put in during the past year, and for the unfailing support they have given the President. I would like particularly to mention our old friend, Mr. Price, who puts in a lot of work for the success of the Institution.

Mr. W. H. WARREN (London): The President and Council have directed the activities of the Institution in a remarkably able manner, and it is therefore a pleasant duty to second this resolution.

The PRESIDENT: In asknowledging this kind vote on behalf of the Council and myself, I would just like to say that the work of the Council is very strenuous, and is not undertaken in any light spirit, neither is time wasted. The Council are businesslike in their methods; and both they and I appreciate your acknowledgment of the fact that we have tried to do our best.

Research and Education Committees.

Mr. C. G. DAWSON (Torquay): It is my privilege to propose a vote of thanks to the Research Committees and the Education Committee for the valuable work which they have accomplished during the year. There is no doubt

THE DINNER AT THE PARK HOTEL.

that these Committees are most important, and very valuable, both to the Institution and to the industry.

Mr. W. CLARK JACKSON (Neath): I have pleasure in seconding this vote. I think that in the past year the Education Committee in particular have proved their value. It is to the young men who are getting the benefit of this education that we shall have to look for the future prosperity of the industry and the Institution. To the Research Committees we are also much indebted.

Dr. E. W. SMITH: I am quite sure that every member of the Research Committees will appreciate this vote, and will feel that the work is a duty and an obligation which it is necessary for them to perform. They will therefore be glad to continue the work, in so far as the Council call upon them to do so.

Mr. TERRACE: As I moved, on behalf of Mr. Goodenough, the adoption of the Education Committee's report, I may perhaps be allowed to reply to the vote for him. The Committee are doing all they can; and the best reward we can get is your approval.

Other Officers and Staff.

Mr. W. B. MCLUSKY (Halifax): I propose that the best thanks of the meeting be accorded to the other officers, the Secretary, and his staff for their work during the past year. We appreciate very much the work that has been done in connection with this great meeting. The excellent way in which the papers have been got up shows that there is much work going on behind the scenes. We recognize that it has been very well done, and because it has been well done we want to place on record our appreciation of the labours of Mr. Price and Mr. Dunn and his staff.

Mr. T. CARMICHAEL (Portsmouth): I would like to second that.

The PRESIDENT: In putting the proposal to the meeting, let me say a word or two in support, for I realize the value of the work done by the staff at Westminster. I would like also to place on record my appreciation of the work done by Mr. Price. He has been my guide, philosopher, and friend throughout my year of office, and I thank him.

Mr. W. E. PRICE: In acknowledging this vote, I wish also to offer my testimony to the sterling worth of the officers of the Institution. Mr. Dunn, as you know, has worked exceedingly hard, and Mr. Winder and other members of the staff are always at hand to render any necessary assistance. As for myself, I can only say that whatever I can do for you, and so long as you wish me to do it, I shall be pleased to undertake.

The Press.

Mr. FRANK WEST: I have to propose that a hearty vote of thanks be given to the Technical and Daily Press for the attention and kindly consideration they have given to the proceedings of the Institution throughout the past year and during the Cardiff meeting.

Mr. S. MEUNIER (Stockport): I shall be happy to second this. I think it is the first time I have had the pleasure of moving or seconding anything in connection with the Press. We know they are invaluable, and we also know the tremendous power they wield—especially the Daily Press. As they have this strength, they might perhaps give us some rather nicer editorials and reports upon gas matters. Possibly if we hear too much about others it is our own fault—because we do not put things in a way that will appeal to the general public. We know full well the value of the Technical Press, and the keen interest they take in all matters connected with the gas industry, and we enjoy the benefit of their wide experience and knowledge.

Mr. ANDREW WILSON: May I be permitted to add a few words in support of this vote? In Australia practically our sole means of keeping posted in affairs is through the Technical Press; and on behalf of myself and my colleagues in that part of the world, I would like to express our appreciation of the invaluable assistance we have received in this way from the "GAS JOURNAL" and the "Gas World." I felt I could not allow this opportunity to pass without letting the representatives of these papers know how much we value their help. We have a lonely furrow to plough, but we are ably assisted by these journals.

The PRESIDENT: It is unnecessary for me to say how deeply we appreciate the Technical Press, and the Press generally. In Cardiff we have a great Press, who have been most helpful to us throughout these meetings.

Mr. CLIFFORD A. KING: It is a very great privilege to acknowledge this vote of thanks. Speaking for the Technical Press, I may say it is not only our duty but our pleasure to be of service to the great organizations of the industry; but this does not mean that we appreciate any less your kind vote. So far as the great Daily Press are concerned, I am not qualified to speak for them; but I think there have been signs of recent times that they are becoming far more "gas conscious." They—especially the provincial papers—are doing more and more for us, and I am sure a vote of thanks passed with such cordiality as this has been will go far to encourage them in that direction.

BENEVOLENT FUND MEETING.

On Wednesday morning, prior to the resumption of the business of the Institution, the PRESIDENT took the chair at the annual general meeting of donors and subscribers to the Benevolent Fund.

The PRESIDENT: I will first of all call upon the Secretary to read the minutes of the last annual meeting.

The HON. SECRETARY (Mr. Walter T. Dunn) read the minutes, and they were confirmed. He then read the annual report of the Committee:

Report of Committee of Management.

The Committee of Management of the Benevolent Fund of The Institution of Gas Engineers have pleasure in submitting their Report for the year 1927-28.

The number of recipients on the list of those to whom the Committee have voted grants is 14. Every case proposed is very carefully considered; a visitor, resident in the town from which the application emanates, is appointed by the Committee. After making full inquiries he presents his report, before any decision is come to in regard to assistance granted.

The Committee refer with much appreciation to the receipt of a donation of £100 from Mr. Henry Woodall, of London, which he sent after the Charter Meeting of the Institution, which was held on April 2, 1928. In the letter accompanying the cheque he expressed his great pleasure at being present at that meeting and desire to convey in a tangible manner his thanks for the cordiality of his reception by the members of the Institution.

There is no doubt that the money subscribed by members of the Institution is wisely spent. Contributors may derive satisfaction from the statement that their act of benevolence is being usefully applied in the relief of those in distress.

Unfortunately, there are still a large number of members of the Institution whose names are not on the list of subscribers. The Committee trust that such members will not neglect to avail themselves of participating in this benevolent work, which must result in enhancing their happiness.

Consequently, if those who do not subscribe would be so good as to do so, their generosity would be most welcome, as it would enable the Committee to take a more generous view of applications for help which they are receiving.

The Committee regret that their colleague, Mr. L. Trewby, felt obliged to resign during the year. In his place they have elected Mr. Chas. F. Botley, who has in various ways always shown a keen interest in the work of the Committee, and has furthered it in a practical manner which manifested itself in his donation during the year under review of the sum of one hundred pounds, kindly given as a memorial of his late wife and father.

The two members of the Committee retiring in 1928, having served three years continuously, were Mr. R. H. Halkett, of Sheffield, and Mr. C. S. Shapley, of Leeds. As successors the Committee nominated, and the contributors to the Fund have elected, Mr. W. H. Bennett, of Redhill, and Mr. G. S. Frith, J.P., of Runcorn.

The financial position of the Fund will be seen from the Accounts for the year ended Dec. 31, 1927, which are appended, duly certified by the appointed Hon. Auditor, Mr. A. E. Broadberry, and Messrs. Wood, Drew, & Co., as will also a list of the donors and subscribers to the Fund during the year ended Dec. 31, 1927. Mr. Henry Woodall's donation has been invested, and the interest on it will be utilized for the purposes which the founders of the Fund laid down.

Mr. E. F. Keable, of Gorleston, who succeeded Mr. Mainwaring, of Lincoln, as Hon. Secretary of the Eastern Counties Gas Managers' Association, becomes *ipso facto*, according to the Rules of the Fund, a member of the Committee in his place.

H. E. MADDEN (President of the Institution), Chairman of the Committee of Management.
W. E. PRICE (Honorary Secretary of the Institution), Joint Honorary Secretary of the Fund.
WALTER T. DUNN (Secretary of the Institution), Joint Honorary Secretary of the Fund.

May 21, 1928.

The PRESIDENT: You have heard the report read; and I now beg formally to move its adoption. I cannot, however, do this without referring to one thing—the very great interest which Mr. Botley takes in the Fund. He showed a very practical interest in it during the past year. The Committee have placed the fact upon record; but I should like to say now how deeply the members appreciate what he has done. His interest is shown not only by his donation, but by his close attention to the details of the Fund. We have commended the Fund to the district Associations; and I would ask the members of these organizations to do their very best. The calls upon the Fund to-day are greater than they have ever been; and we can do with more money, in order to put things on a more substantial basis. I beg formally to move the adoption of the report of the Committee of Management.

Mr. J. FERGUSON BELL (Derby): In seconding that, I should like, if I may, to refer briefly to the generosity and practical sympathy accorded to the Fund by our friend Mr. Botley. He has always taken a very great interest in it; and he has shown his sympathy in a way which will commend itself to every member of the Institution. We are glad to know that the Fund is in a healthy condition; but during the last year or two there has been a large increase in the membership of the Institution, which possibly means in the future greater demands upon the Fund.

A Good Suggestion.

It has therefore occurred to me that, if we get our Royal Charter, it would be a very nice thing if we could place this Fund in a thoroughly safe and sound position—in such a condition, indeed, as would enable us to give more generous aid to those in need of it. ["Hear, hear."] I know from my association with the Benevolent Fund what good work it does. As the report says, the money has been spent wisely and well; but if you will look at the total number of subscribers, and at the total number of members of the Institution, you will agree with me that there are some more who might subscribe.

Mr. C. DRU DRURY (Sunderland): It seems to me that only about 40 p.ct. of the members of the Institution contributed last year to the Fund; and the appeals made seem more or less to fall on deaf ears. There is a very great deal of room for improvement; and I suggest that, when notices are sent out for the renewal of subscriptions to the Institution, some prominent appeal should at the same time be made for the Fund—either by enclosing separate subscription forms or by attaching them in some way to the subscription form of the Institution. I do not know exactly what course is adopted at present, because I have adopted the plan of signing a banker's order for payment direct; but I should think that something special might be done to bring the Fund before the large number of new members and associate members of the Institution. Another thing which would be likely to increase interest in the matter is a little more detail with regard to the manner in which the money is spent. I fully agree with the statement in the report that there is no doubt the money subscribed is wisely spent; but interest would be aroused if (say) the initials were given of those who benefit, and probably a larger number of subscriptions would result.

The PRESIDENT: I would like to say at once that when the Institution subscription forms are sent out, there is a space left below for the Benevolent Fund. Thus members when they pay their subscriptions to the Institution can at the same time put underneath their contribution to the Benevolent Fund, and send in one cheque for the two. With regard to showing how the money has been spent, it is very difficult at times to do this. I have learned this from my experience during the past year. The question of publishing the information has been before the Committee; but after very careful consideration it was felt that it would be better not to do so. Peculiar cases occur, which have to be dealt with in peculiar ways; and altogether the Committee do feel that it would be inadvisable to publish details of how the money is spent. The stewardship is in very strict hands. The accounts are examined very carefully by the Finance Committee of the Institution; and I would like you to trust the Committee to continue in the same way as hitherto. I am much indebted to Mr. Bell for the excellent suggestion that, when the Royal Charter is received, members shall show their appreciation by sending a special donation to the Benevolent Fund. If there are no other remarks, I will put to the meeting the motion for the adoption of the report. It is carried unanimously. That concludes the business.

THE PRESIDENTIAL ADDRESS

OF

H. D. MADDEN, M.Inst.C.E., M.I.Mech.E.,

Engineer and Manager to the Cardiff Gas Light and Coke Company.

GENTLEMEN,—It is now my duty to present the Presidential Address. This I have felt must be, to some extent, an account of stewardship, for my year of office is drawing rapidly to a close. A year ago, when you elected me as President of the Institution, and, for the time being, titular head of the gas industry, you honoured my Company as well as myself. This is the first occasion the honour has come to the Principality of Wales.

The past year has been one of great development for the Institution. Our rules have been amended, and the qualification for membership will be largely governed by technical knowledge and entry by examination. We meet this year in the expectation that the honour of a Royal Charter will be granted to us, so increasing the status of our membership and Institution.

I might wish that an abler pen than mine could trace historically the progress of the gas industry which has led up to this great event. The history of the public service which we give is written in the pages of the past 120 years, for it is so long ago since Pall Mall, in London, was first lighted by gas. To-day it is lighted by (high-pressure) gas with a brilliancy and at a cost unknown and undreamt of in those early days. It is 116 years ago since the present Gas Light and Coke Company received its Royal Charter of Incorporation, and to-day that great undertaking is not only the largest in the world, but actually supplies more energy (in gaseous form) than all the electricity undertakings in Great Britain combined.

NOBLE PIONEERS.

As we look backwards through the misty ages of gas supply, William Murdoch, 1754-1824, Samuel Clegg and Winsor, 1806, John Malam, and John Grafton, the early pioneers of gas supply to the public, laid the real foundations for this Institution, for they made possible, by their early efforts and investigation, processes whereby the spirit of coal could be utilized for the benefit of mankind. It is true there had been earlier investigators who in the 17th century, with limited chemical knowledge, discovered that coal could provide inflammable gas; and we in Wales claim that a Bishop of Llandaff was one of those pioneers who investigated the production of inflammable vapour from our local coals.

On through the pages of the history of gas progress, we come to the name of Sir George Livesey, that great and pioneer engineer, who not only swept away many shibboleths that stood in the path of our progress, but also brought to our industry the principles and application of co-partnership. Then there were Sir Corbet Woodall (sometime Governor of the Gas Light and Coke Company), engineer and administrator of great personality, wide perspective, and parliamentary ability, and also an honoured Past-President of the Institution; Lord Moulton, lawyer and scientist, who was made Director of High Explosives during the Great War, also a Past-President of this Institution; John West; Sir Dugald Clerk; and that great investigator, Sir William Perkin, who, in 1856, discovered the aniline dyes.

To these and other pioneers in research, whose names are emblazoned in our history, the Institution owes an undying debt of gratitude. Many of them were members of the present Institution or its forerunner; and if we rejoice to-day in expectation of a Royal Charter, let us remember with gratitude the names of famous men who blazed the trail and helped to bring this honour within our reach, and, we hope, our possession and heritage.

EDUCATION IN THE INDUSTRY.

It was left to Walter Grafton, one of our members, now of Glasgow, to recognize the need of applied technical education in our industry. The formation of a Junior Association followed as a sequel to the advance of this technical education; and these Associations are a live and educative force in the ranks of our organization. The pressing need of an education scheme to cover all branches of our industry became imperative; and exhaustive and indefatigable endeavour has resulted in this need being satisfactorily supplied. Then another step to advance the education scheme was the revision of the rules of the Institution; and when that work was undertaken, the vision of the possibility of a Royal Charter was ever before the framing Committee. If any vindication of this course is necessary, the recent large additions to the ranks of the Institution bear witness.

Gentlemen, to-day we begin to see the fruition of the labours not only of ourselves, but of those grand pioneers who made these things possible. We are confident that the younger members who can read the rede will carry on the torch of progress of this great Institution, and teach their juniors in turn the true traditions of the work and service of those who went before and also served.

May I direct your attention to the work and reports of the various Sub-Committees of your Institution. Year by year the activities of these are extending, thereby indicating development and expansion of interests. It would be out of place to deal with these in detail, for you will receive the report of each Sub-Committee duly set out; but the growth of this detailed work indicates progress in research relative to this great expansion of interests and the wider ramifications of our business.

GAS AS A CURATIVE AGENT.

Perhaps the most striking report, at least to my mind, is that of the Sub-Committee entitled "Gas for Clinical Purposes," on the uses of the combustion of gas for therapeutic cures. This investigation is likely to produce valuable information in reference to the qualities of radiant heat emanating from gas fires, and the application thereof for curative purposes. Sir Henry Gauvain, as you know, is conducting researches at Alton, Hants., and the members of the Sub-Committee are gentlemen of high scientific attainments, and especially capable for the development of the investigations.

We shall welcome the results of the investigations by Dr. Carpenter and the South Metropolitan Gas Company, as well as other bodies and scientists who are examining the health-giving curative properties of the rays emanating from gas fires. It appears quite possible that great advances will be made in this direction by the utilization of certain materials for the radiants of gas fires.

EFFLUENTS AND GASHOLDERS.

I would commend to your notice the report on the investigation of spent liquor effluents. The subject offers the greatest difficulties, but I venture to think that the problem will be solved by the active minds of its Chairman, Mr. Botley, and the members of the Effluents Committee.

With the ever-developing work of our Institution, a new Committee has come into being during the past year, and has already performed useful work on your behalf. I refer to the Committee on Gasholders. We have the admirable guidance of Mr. Doig Gibb, as Chairman, and

your Council have recognized and placed on record the valuable work done by the Junior Vice-President, Mr. Shapley, and two colleagues during the period under review. For too many years this subject has lacked the attention it merited. With the exception of increased capacities, very little investigation has been made on this important plant. The advent of the spiral-guided holder, and more recently the tankless holder, in combination with moisture-freed gas, has re-opened a field of investigation which merits, in the opinion of your Council, a standing Committee to keep in close touch with all questions affecting the structure, care and upkeep of our storage plants.

The Magnitude of Our Industry.

In the midst of our daily round and common task, it is well to pause and consider sometimes what our industry stands for, what it has achieved, and at the same time to endeavour, with a wide view, to ascertain what the future has in store—or, to put it in a different way—with what breadth of vision can we visualize for our business a continuous and increasing development? Its infancy and growth have been referred to previously. To-day we stand in the position of being the chief and largest exponents of the art and practice of the carbonization of coal. As an industry, we carbonize some 17 million tons of coal per annum for gas production; and we carbonize this quantity in the most efficiently commercial manner yet known—obtaining thereby a thermal efficiency as high as 80 p.ct. of the original coal, translating this for the uses of mankind, and supplying our gas service through approximately 9 million meters to some 30 to 40 million inhabitants of this kingdom.

If more efficient methods of manufacture can be found, then, as practical propositions, the gas industry will be in the vanguard to adopt them, and will not fear to scrap older and less efficient plant; for we claim that a true commercial instinct balances and governs the engineering decisions of our profession. Above this is realized the outstanding idea of service, in its truest meaning, to the public we have the honour to serve with the means of light, heat, and power, together with many series of chemical products which can be obtained only by the constructive distillation of coal. I say "constructive" advisedly, since the phrase "destructive distillation," to my mind, can only be used to describe the alternative methods of burning raw coal in a grate (as an open fire) or under a boiler, or in such other methods whereby the lowest heating efficiency is obtained from the coal, while the valuable constituents are driven off and pushed up the chimney, with consequent pollution of the atmosphere, with its attendant evils of destructive effects on buildings, lessened sunshine, increased dirt, diseases of darkness, grime, and labour. Surely this method is destructive carbonization, while the gas-works and coke oven works system is, in substance and fact, truly constructive in its method and application.

During the Great War, the carbonizing industry of Great Britain supplied the bulk of the high explosives, antiseptics, and other articles of warfare for the Allied Armies. It is always well to keep this utility of our industry for potential defence before our countrymen.

During the coal stoppage of 1926, for seven months our undertakings supplied the homes of millions with light, heat and fuel; and the magnitude and full meaning of this has never been realized by the man-in-the-street, or admitted by the politician or by the Government itself.

The great new system of arterial roadways, as well as the earlier and older roads, can depend upon our industry for supplies of manufactured tar, &c., for road-making; while the agriculturist can look to us for fertilizers, and the dye and colour industries for the supplies of their raw materials. These are not all, for we supply the electricity industry with their solid carbon, which is vitally necessary in the construction of electrical plant.

Recent Changes.

It is remarkable to note the changes that have taken place during the comparatively short time I have had the honour to serve in our industry. I well remember the practically universal use of gas for street and house lighting, and, upon the introduction of electricity for lighting and power, the controversy which occurred as to their relative future prospects. I have lived through a period when a 90 p.ct. lighting load of the gas industry has been translated to a 90 p.ct. heat and power load; and, marvellous to relate, concurrently the output of gas has been more than quadrupled, while its extended use in new directions ensures continued progress.

Notwithstanding the alteration of the loads, I am a great believer in the value and retention of the lighting load. Modern fittings and burners provide the cheapest, cleanest and healthiest form of lighting for the dwelling-houses of the ordinary consumer. Light, warmth and ventilation are provided by incandescent gas lighting at an average burner cost of one penny for five hours.

The relative position of the two services may be more accurately gauged by expressing the supply of gas and electrical energy in comparable heat units, in any town where both services are in use. Disregarding the use of electricity for tramways, and confining the comparison to purely domestic service, it would appear that the quantity of electricity used is approximately 10 p.ct., as against 90 p.ct. use of gaseous fuel supply; the latter, and, indeed, both, showing good annual increases chiefly for domestic and trade heat purposes. For 1926, Butterfield stated that the gas output showed an increase of 54,056,470 therms over the previous year, against an increase of 7,165,801 therms for electricity; the ratio of gas increase to electricity increase being 7·54 to 1. To the most timid of believers and investors, truly these facts and figures must be a *sursum corda* to inspire confidence.

The question of coke supplies to the cities and townships has yet to be added to the above, if the true potential heat energy supplied by the gas undertakings is under review and examination. These figures may be startling to the public mind, but are familiar to us who have had experience of the development of the gas industry and the corresponding appreciation of its services by our consumers. It is evident that the public mind is changing, and beginning to regard with increasing displeasure the idea of the coal fire with its smoke, dirt and ashes, and the heavy household labour inevitable with this method of domestic heating.

Throughout the kingdom, year by year, in our industry, reports of undertakings bear wide witness to the fact that the supply of gas cookers, fires, water heaters, &c., for domestic use is increasing at a rate unexpected and undreamt of a few years ago. The enormously increasing use of gas for trade and industrial purposes is a revelation of the extensive application of gaseous heat, and is coincident with the gradual disappearance of the coal and ash carts from our streets. These facts indicate not only an appreciation of a supply of clean, smokeless, gaseous fuel which can be turned on and off by a tap, but that public opinion is still the great deciding factor in the relative advantages of the different forms of light and heat for domestic requirements.

Need for Efficient Sales Organization.

The canvass inspection of most districts reveals the fact that approximately 96 p.ct. of our town houses are supplied with gas cookers—a figure practically indicating saturation point, if shops and closed premises are taken into account. Notwithstanding this fact, consumers appreciate the modern high-grade cookers, and are busy installing them in place of earlier types.

The use of modern gas fires having the advantages of radiant heat and healthy conditions of ventilation, is finding rapid favour with housewives, while water heating is forging ahead, especially so with the application and installation of the gas-heated wash-boiler, which is so great an advance on the old type of brick-built, coal-stoked copper. So, too, with the greatly extended use of gas for trade and industrial heating problems. Gentlemen, the field of both domestic and trade uses of gaseous fuel, already large, is extending at an enormous rate throughout the country; and this being so, it is vitally necessary that every undertaking should have a live and educated outdoor department staff that can cope with all the problems which may arise, so efficiently that the consumer is

given the highest form of service. Any undertaking which neglects to organize its consumers' service on the highest plane is guilty of negligence not only of its own interests and those of its consumers, but of the industry generally. Further—cheap gas without good and efficient service is like Faith without Charity—it is nothing worth.

Examining the possibilities of increasing output of gas, it will be found that the greatest use of gas *per capita* is in the United States of America, where the cost per thousand is dear compared with this country :—

In Washington the consumption *per capita* is								12,837 c.ft.
,, San Francisco	,,	,,	,,	,,				12,392 ,,
,, New York	,,	,,	,,	,,				12,325 ,,
,, London	,,	,,	,,	,,				10,100 ,,
,, Sheffield	,,	,,	,,	,,				9,214 ,,
,, Bristol	,,	,,	,,	,,				8,172 ,,

Gentlemen, if the United States of America, which is a stronghold of electricity supply, and where the consumption of electricity is three to four times greater *per capita* than here, can yet lead the way in gas output, it is evident that there is in this country a large field of possibility, which only requires proper development.

It is apparent from the Daily Press that a great and growing interest is being taken by the public generally in the carbonization of coal, and the provision of oils, tars and fuels from this process. A greater perspective and vision obtains to-day on this matter. Some few years ago, the glamour of the word " electricity " for all purposes overshadowed the truth of the practice of the proper utilization of coal for national and domestic needs. Not only the public, but leading politicians are now turning their interest to the carbonization of coal in one form or other; and it is apparent that there has been a general awakening to the great future possibilities of the processes we adopt for the treatment of coal. As an industry, we desire to develop sturdily, as we have done for a hundred years past, having entire freedom from political interference and Government restrictive control.

General Interest in Carbonization.

Other evidence of the reversion of outside interest to carbonizing methods of coal treatment may be readily observed. The Carbonization Congress recently held in Birmingham, and the discussions on the papers, are indicative of this fact. The transactions of the newly formed but highly specialized Institution of Chemical Engineering and the Institute of Fuel show that carbonization of coal takes a leading place of interest. Gentlemen, the pendulum has swung. The interests of cultured and scientifically trained minds are focussed on the question of the future development and possibilities of carbonization, with the co-ordination and economical utilization of the whole of the fuel resources, including waste or surplus heat, in Great Britain.

In our industry there are many problems which require chemical and physical investigation to widen the scope of our development; and the words of wisdom uttered by Mr. T. Hardie, Chief Engineer of the Gas Light and Coke Company, recently, before the newly formed Western Junior Gas Association, are worthy of repetition. They were as follows :—

" We must also consider any departures from accepted practice which would have the effect of increasing the income from our plant by the creation of additional bye-products, and in this way reduce the price at which we can sell the principal commodity. Gas manufacturers are the largest producers of hydrogen and carbon monoxide in the country; and they could during the summer months economically operate idle plant for the production of these gases—not for sale as gases, but for conversion into other commodities. These gases are very important in some industries just emerging from the experimental stage. The production of methanol and synthol, the manufacture of synthetic ammonia, and the hydrogenation of coal, could all be accomplished, possibly with considerable profit, at many large gas-works. Remembering the speed at which successful research and experimental work may be translated into commercial operation, it behoves all interested in gas manufacture to keep in the closest touch with these developments."

It is also well to review the intense and rapid development of the Imperial chemical industries, and the ever-widening sphere of chemical products. These are realized as the result of co-operative effort, close investigation, and research. With such a wide vision before us, it is imperative that the gas industry should attract to its ranks public school men and men of the best calibre, to carry on the future developments; and I would make an earnest appeal to the boards, committees, and directing bodies of all gas undertakings to offer such remuneration as will readily attract to their services and the industry the best and highest educated type of men.

The Question of Remuneration.

As an industry, we must be in the march of the great chemical and industrial advance which is already in being; and to do this it is imperative that the administrators, and also the recruits to the service, should be men of education, intellect, and character, and, further, they must be well and adequately paid for their specialized knowledge, ability, and service. It is disturbing to note the low salaries at times offered for various appointments. Surely such terms cannot attract the proper type of candidate; and the undertaking and the industry ultimately suffer.

With our amended rules, and the higher plane of entry required by the Institution, we may, and do, reasonably expect that the men who so qualify shall be properly remunerated, and thus encouraged to give of their best to the undertakings they have the honour to serve. Cheap labour is not economical in the long run, or, indeed, under any conditions. The financial advantage of skilled supervision is a huge item compared with infinitesimal savings in salaries.

The past year has brought lessons and experience in its train. Gas outputs and the sales of gas-consuming appliances advance steadily, and there is a general and necessary trend to the supply of a gas of constant calorific value, specific gravity, and pressure. Carbonization is a progressive science, and the yield of therms per ton of coal carbonized is increasing; while the reclamation of surplus heat is a problem that is receiving more general attention.

Coke and Bye-Products.

Skilful coal blending, for better coke manufacture, is being more closely examined and adopted, but there are still too many undertakings who look upon coke as the solid residue to be pushed out before the next charge is placed into the retort, and to be got rid of as speedily as possible. If we are to hold the domestic coke market, more skilled supervision and attention must be given to the manufacture and preparation of this product. As one who has had some years' experience of coal blending and coke grading, it is certain that there is yet a large field undeveloped for the utilization of graded smokeless coke; and the industry that has the advantage of possessing selling agencies already organized in its offices and showrooms must perforce pay every attention to the manufacture and preparation of this important product, which is the second largest item in the revenue side of our accounts, for the coke oven and low-temperature organizations are looking with a covetous eye at this great field of smokeless fuel supply.

Tar has held its own, and must be kept at a price that mutually pays producers and buyers. The British Road Tar Association has come into being, and " British Tar for British Roads " is its watchword. With the great depression in the Welsh coalfield, no apology will be necessary if the words " Welsh Tars for Welsh Roads, made from Welsh Coals " are adopted for this district.

Sulphate of ammonia as a product is suffering from the competition of the newly developed synthetic process, which has advanced rapidly in principle and production during recent years. Our industry must investigate as rapidly as possible new outlets for our heavy production of ammonia; and on this question, praise must be given to the Yorkshire Section of the Manchester District, who moved so rapidly in the matter, and supported their request for immediate investigation by a solid grant of money to the Institution.

Co-Partnership.

The trend towards the adoption of co-partnership is gratifying. Many company undertakings are now work-

ing under its beneficial influence. Its terms make for security of tenure, harmony of working, and financial and other advantages to the workmen and staff; and under many systems the interests of the shareholders, gas consumers, and workmen and staff are indelibly bound together. If the principles of co-partnership could be extended to all undertakings in our industry, I am sure nothing but good would follow in its train.

STATE-RELIEF.

At this juncture, I should like to make some brief reference to the promised rating relief to productive industries, as outlined by the Chancellor of the Exchequer in his recent Budget statement. If the gas industry is debarred from participating in this, it will be a grave injustice not alone to the gas industry itself, but to many millions of gas consumers, such a large proportion of whom belong to the working class.

It may be asked, What of the industry of Wales? Gentlemen, it is full of hope; and we are proud, and assisted in our future work and outlook, to think that this is the first occasion on which the Institution has given the honour of Presidency to the Principality, and the first occasion for them to hold their meetings here.

The Principality is rich in coal, but not in gas coals; and the undertakings in this country have difficulties of manufacture and distribution practically unknown in many other parts of Great Britain. In Cardiff the supply of gas was available in 1820-21; and from a small beginning, the present Company, with its 68 square miles area of supply, has developed. The details of its history, works, and showrooms, &c., are portrayed in a special brochure; and there is no need to reiterate the recital of this work, which will soon be in your hands. However, it may be interesting to know that when your President first came to Cardiff some 21 years ago, there were three undertakings supplying gas, and four works manufacturing gas. By amalgamation and joint working, manufacture has been concentrated at one place—viz., the Grangetown Works—and the consumers of the outlying districts are receiving the benefit to-day. The price charged per therm is the same throughout the district of supply as in the City. The consumers' service is equally efficient, and there is the added benefit of local offices and showrooms.

BENEFITS OF AMALGAMATION.

There is no question that co-operation, amalgamation, and joint working between large and small gas-works must bring in their train benefits to the consumer, by reduced capital expenditure, lower costs per therm, and the advantages of concentrated and experienced staffs and organizations. The Company's works, showrooms and Bute Terrace distribution offices and stove and meter repair shops are, by the courtesy of my Chairman and Directors, open for your inspection.

Since the advent of electricity in this city, the output of gas has been trebled. Our industry is now represented by three national bodies, each having separate existence, but united together by strongly forged connecting-links; and each one carries out specialized and defined duties. Whereas for many years The Institution of Gas Engineers carried out practically all the technical and most of the other duties of the industry, some years ago it became imperative that publicity and consumers' service should become a specialized branch; and the British Commercial Gas Association was founded. Later it became absolutely necessary that the gas industry should have a united national mouthpiece that could speak on behalf not only of the officers of the undertakings, but of the directors and managing committees. It is unnecessary for me to detail to you, Gentlemen, what great work these two added bodies have done; but during the war and post-war years, and the coal stoppage period, the assistance and guidance all of us have received from them prove that their foundation was not laid a moment too soon. If it is desired to see the results, the trustees of the gas industry may well quote Sir Christopher Wren's epitaph in St. Paul's Cathedral, "*Circumspice*" ("Look around").

FUNDS FOR RESEARCH.

One appeal I would earnestly make from this chair is on the subject of the funds for research work. The Institution is doing its best with the funds available and the great amount of volunteer individual work; but there is no question of doubt that the future of the industry and its prosperity rest on research and investigation. While this work is in the hands of the Institution, we must have adequate funds to carry on and develop it.

The capital invested in the gas industry is enormous—over £140,000,000—and future problems for expansion and the development of coal and residuals, form a field almost indefinable. This being so, research and investigation, and the provision of qualified technicians, should not be grudgingly given, if the magnitude of the possibilities of development is viewed from a proper perspective.

THE FUTURE.

Gentlemen, in conclusion, What of the future? Unquestionably, with a broad view, the prospect is a good one, but we have to be mindful of the fact that the gas business is largely dependent on the charges we make for gas, and that these charges are considerably governed by the markets of your secondary products, and are also affected by the incidence of rates and taxes. We have noted the competition that has been developing in regard to our secondary products, and we have to meet it—not only to meet it, but to keep in advance of it—which object will only be attained by the adoption of science, commonsense, and concentration. Coke of rough and low physical characteristics must be abolished, and we must sturdily cultivate our local markets with specialized products—especially so when we realize that something like 36 million tons of coal are used for domestic purposes. Gentlemen, that market must be our objective. We must replace it by well-prepared coke—our smokeless fuel.

The concentration of electricity production stations under the super-power scheme will relieve individual station engineers from generation, and they will concentrate on sales development. Competent men with good organizations in our industry will not fear this, as they realize and know the strength and weaknesses of our rivals, and are not afraid to meet them in open and true competition.

Gentlemen, you know the potentialities of the gas industry. If these are well and truly developed, stability and progress must inevitably follow in its train, so that our industry may sturdily and rapidly become the suppliers of smokeless and gaseous fuel both to-day and in the future. Let us say, *Floreat!*

THE NEW MORRISTON WORKS OF THE SWANSEA GAS LIGHT COMPANY.

By W. H. JOHNS, M.I.Mech.E.

This paper has for its theme the first complete unit of a new works at Morriston which the author has had the privilege to design and erect for the Swansea Gas Light Company; and while it is supplementary to his Presidential Address to the Wales and Monmouthshire District Institution of Gas Engineers and Managers in October, 1924, when he described the Coal Gas Section, he trusts he will be successful in evoking the interest of the members of this Institution in describing the complete unit of works, comprising the coal gas and water gas plants.

The Swansea Gas Light Company was established in March, 1821, commencing with a works in Dyfatty Street, and was incorporated in 1830 by Act of Parliament.

In 1840 the Company found that its works in Dyfatty Street (confined to a restricted area) was not sufficient in capacity to meet a constantly increasing demand for gas. Accordingly, a site at Oystermouth Road was acquired and new works were constructed; gas-making apparently being commenced in 1841, when the works at Dyfatty Street were abandoned and sold.

Thereafter, the Company maintained a continuous record of progress, and the extension of its activities was so remarkable that by the year 1912 it became apparent that, as no practical scheme of reconstruction was possible at the works at Oystermouth Road, the resources of that works would ultimately be outstripped.

In 1912 statutory powers were successfully sought to acquire additional land at Morriston, but the preparations made in 1914 for constructing new works were unavoidably postponed by the outbreak of war.

In 1919 the necessity for increased storage accommodation became so acute that a contract for a gasholder was placed; but inflated values and the consequent diminished purchasing power of money influenced the Directors to postpone capital expenditure in respect of manufacturing plant at least for a few years.

In 1922, however, the contracts for carbonizing and relative auxiliary plant were placed. Such contracts were completed in September, 1924, when the coal gas section at Morriston was commissioned and superseded the coal gas section at Oystermouth Road. In 1926 contracts for the carburetted water gas section were placed; the section being completed and commissioned in March, 1927.

During the years 1925 and 1926 the manufacture of coal gas was conducted at the Morriston Works, and the manufacture of water gas at the works at Oystermouth Road; the gases being mixed in the holders at Oystermouth Road, which are connected by a high-pressure main to the Morriston Works.

In March, 1927, gas manufacture was abandoned entirely at the Oystermouth Road works, which are retained as a distributing station and central stores.

THE MORRISTON GAS-WORKS.

The Morriston Works, shown in block plan with explanatory key in fig. 1, are laid out for an ultimate capacity of 12 million c.ft. of coal gas and 6 million c.ft. of water gas per diem.

The unit of works which has been completed comprises coal gas plant and carburetted water gas plant having respective nominal capacities of 3 and 2¼ million c.ft. per diem, and a reserve carburetted water gas set having a nominal capacity of 1¼ million c.ft. per diem.

The principal sections of plant are:

Gas Manufacturing:

Horizontal retorts, with a Drakes combined charging and discharging machine and a "G.N." hot coke transporter.

Humphreys & Glasgow water gas plant.

Coal Stocking:

A steam locomotive crane in conjunction with an open yard heap.

Coke Handling:

A ferro-concrete quenching bench; a locomotive crane travelling on a ferro-concrete gantry; ferro-concrete storage hoppers with overhead cascade screens.

In designing the new works, the peculiar influences which affect the choice of plant were duly considered in the endeavour to co-ordinate the agents of gas production in such a manner that their combination would be most effective. Naturally, such influences are not immutable, but the following principles prevailed:

(1) Relative convenience of geographical situation of the site, and its suitability for the reception of heavy works, and their subsequent extension.
(2) The selection of plant most capable of satisfying particular local conditions.
(3) Rapidity and efficiency of mechanical control.
(4) The maintenance of a proper relation between productive capacity and present demand, and productive capacity and estimated future demand.
(5) The maintenance of a proper relation between capital cost and productive capacity and between capital cost and present demand.

THE SITE.

The site of the Morriston Works consists of 45 acres of fairly flat marsh land in the valley of the River Tawe midway between Morriston and Llansamlet, and adjoining the river bed.

A geological report states the valley was formed during the glacial and post-glacial period when ice from the high plateaux of the hinterland descended to the sea. The depth of the superficial deposit varies considerably. In one place the glacial formation is over 300 ft. in thickness, while in coal pits, not far removed from the gasworks site, the rock of the upper coal and the pennant series have been encountered at depths varying from 50 to 60 ft.

A report describing the sinking of a shaft in 1863 states: "The tract contains a bed averaging about 60 ft. deep of clay, quicksand, and alluvial soil. It is supposed that it was once a lake, and this is probable, as old trees and other similar remains were found at a depth of 20 ft."

Extensive boring revealed the nature of local subsoil, indicating that prevailing substrata were mud, sand, ballast, and blue boulder clay; the thickness of each substratum varying to such an extent that it could nowhere be relied upon. Measurements taken from a series of boreholes showed considerable variation, and typical sections through adjacent boreholes are shown in diagram in fig. 2.

The physical structure of the site is rendered more difficult by climatic conditions. The local rainfall is very heavy, and during the winter months the site at its natural level is flooded continuously. But the geographical relation of the site to industrial Swansea, and particularly to those districts where industrial development is most likely, is favourable; and notwithstanding physical disadvantages it is difficult to see where a better site could be acquired from a distinctly limited choice of land.

FOUNDATIONS.

That part of the site immediately required for the reception of works was made up to the extent of 7 ft., and fortunately adequate supplies of excellent filling material were available at adjoining industrial works.

At the outset it was realized that the choice of foundations would require particular consideration. Various suggestions presented themselves:

(1) The construction of rafts on the made-up ground.
(2) Raft foundations at marsh level.
(3) Mass concrete or raft foundations at gravel level.
(4) Reinforced concrete piled foundations.

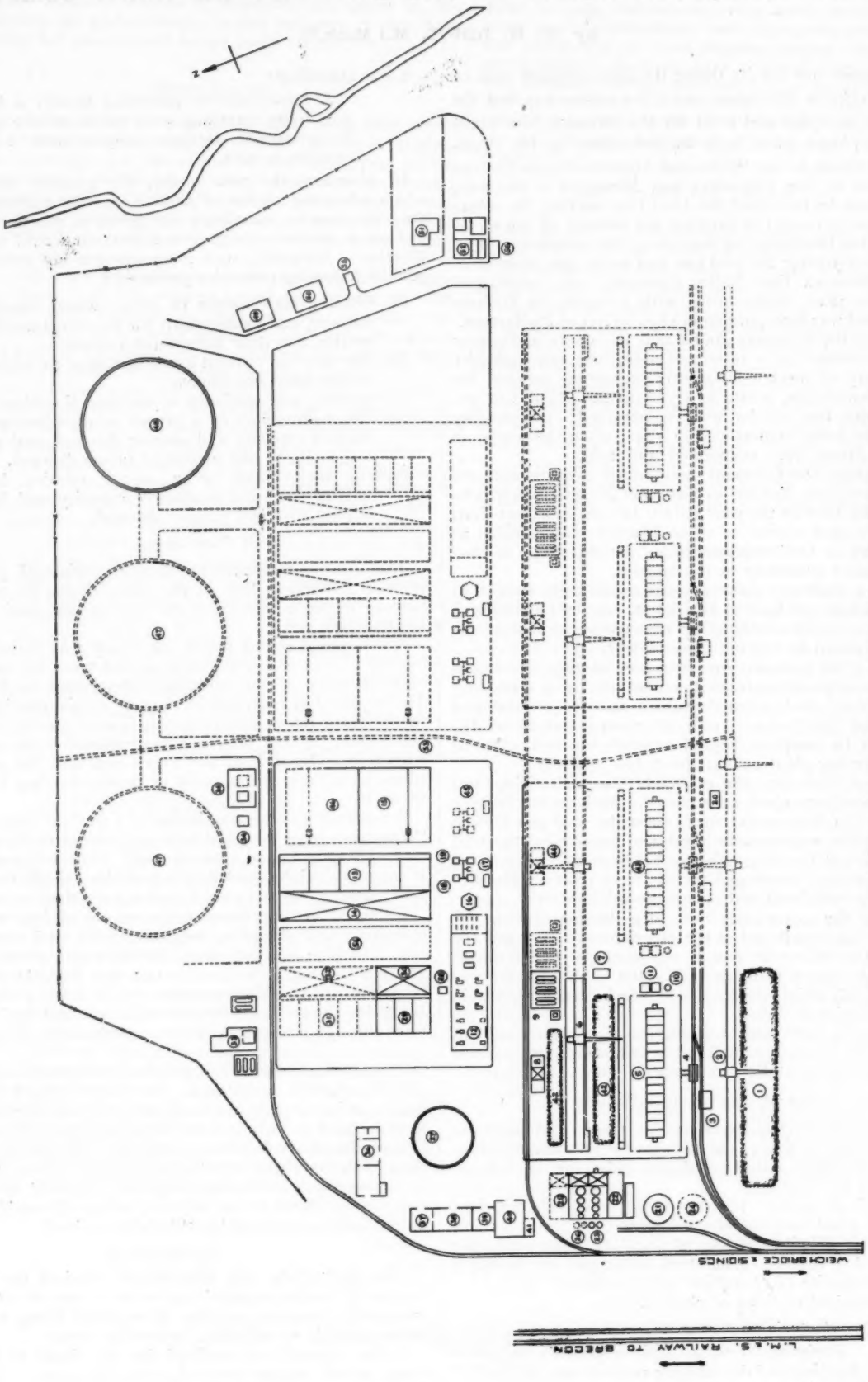


FIG. 1.—SWANSEA GAS LIGHT COMPANY, MORRISTON WORKS.

The merits of each proposal were influenced by :

(1) Capital cost.
(2) The nature of the loads to be carried.
(3) The degree of consolidation of the made-up ground.
(4) The softness of the alluvial clay.
(5) The irregular contour of the gravel bed.
(6) The prevalence of mud pockets.
(7) The prevalence of fine or running sand, and the creation of running sand through disturbance by excavation, pumping, or pile driving.
(8) The varying resistance offered by the site.

It was abundantly clear that foundations of any type would be comparatively costly; and in exploring possible sources of economy every care had to be exercised to ensure that stability would in no way be sacrificed.

Comparisons in cost and design revealed that reinforced concrete piled foundations were the least costly, consistent with stability; and accordingly foundations of this type were adopted for the greater portion of the works.

The next consideration was the type of pile. The broad divisions are :

(1) Pre-cast piles; and
(2) Piles cast *in situ*.

Observations made from the driving of a few pre-cast test piles indicated that the piles would have to be at least 30 ft. in length, that it was impossible to forecast whether piles even 30 ft. long would be satisfactory, and that in all probability the original carrying capacity of many piles would have to be improved.

KEY TO BLOCK PLAN

1.—No. 1 Section Coal Stock.
2.—No. 1 Section Coal Grabbing Crane.
3.—No. 1 Section Coal Grabbing Pit, Coal to Stock.
4.—No. 1 Section Coal Breaker Pit.
5.—No. 1 Section Retort House, 3 Million C.Ft. Capacity per Diem, with Coal and Coke Handling Plant.
6.—No. 1 Section Coke Crane Running on Reinforced Concrete Gantry.
7.—Columbus Coke Separator.
8.—No. 1 Section Coke Storage Hoppers.
9.—No. 1 Section Boiler House, Prepared for Reception of No. 2 Section Boilers.
10.—No. 1 Section Cyclone Tar Extractor.
11.—No. 1 Section Water Cooled Condensers.
12.—Engine House containing No. 1 Section Electric Generating Sets, Exhausters, Compressors, Tar and Liquor Pumps, and prepared for No. 2 Section Sets.
13.—No. 1 Section Coal Gas Purifiers.
14.—No. 1 Section Coal Gas Purifiers Revivifying Floor.
15.—No. 1 Section Tar and Liquor Wells with Separator.
16.—Elevated Water Tank.
17.—No. 1 Section Livesey Washer.
18.—No. 1 Section Ammonia Washer Scrubbers.
19.—No. 1 Section Naphthalene Washer Scrubbers.
20.—Water Sump.
21.—C.W. Gas Oil Storage Tank.
22.—C.W. Gas Plant.
23.—C.W. Gas Condensers.
24.—Future C.W. Gas Oil Storage Tank.
25.—Future C.W. Gas Plant.
26.—Future C.W. Gas Condensers.
27.—C.W. Gas Relief Holder.
28.—C.W. Gas Naphthalene Washer.
29.—C.W. Gas Purifiers.
30.—C.W. Gas Purifiers Revivifying Floor.
31.—Future C.W. Gas Purifiers.
32.—Future C.W. Gas Purifiers Revivifying Floor.
33.—Tar Dehydrating Plant.
34.—C.W. Gas Meter.
35.—Meter House containing No. 1 Section Meter and prepared for No. 2 Section Meter Coal Gas.
36.—Sulphate of Ammonia Plant.
37.—Blacksmith's Shop.
38.—Machine Shop.
39.—Carpenter's Shop.
40.—General Stores.
41.—Oil Stores.
42.—Coke Storage on Yard.
43.—Future Retort House.
44.—Future Coke Crane and Coke Storage Hoppers.
45.—Future Washers and Scrubbers.
46.—Future Tar and Liquor Wells.
47.—Future Gasholders.
48.—Gasholder, 2 Million C.Ft. Capacity.
49.—Governor House.
50.—Laboratory.
51.—Works Superintendent's Residence.
52.—Offices.
53.—Culvert Line.
54.—Future Coal Gas Purifiers.
55.—Garage.
56.—Road Traffic Weighbridge.

The character of the site brought about the adoption of pre-cast piles (see fig. 2), partly because :

(1) They can be easily reinforced.
(2) The regularity of their structure is definitely known.
(3) They are set, and therefore permanent, before driving.
(4) The carrying capacity attained on the initial driving can be improved by resting and redriving, and/or lengthening *in situ*.

Actual experience in pile-driving proved the advantages of precast piles to be real, and even greater than were anticipated. The piles were cast 10 in., 12 in., and 15 in. square, and 30 to 34 ft. in length; and, as anticipated, the original sets of many were not satisfactory. Such piles were therefore rested for a few days and re-driven, and often improved, and reliable sets were immediately recorded. The explanation of the improvement was that the piles had been driven into pockets of fine sand which had assumed a semi-liquid state when vibration was set up by pile-driving and had re-consolidated when pile-driving was suspended. If " resting " did not result in improved sets, the piles were lengthened *in situ;* and for this purpose Ciment Fondu, a quick hardening aluminous cement, was employed.

The average cost per square foot of raft was 13s., and notwithstanding extensive pile-driving there is no doubt that the type of foundation adopted was the most economical, and that in the special circumstances the total cost was not unduly heavy.

The foundations of the smaller buildings and less important structures such as works residences, offices, laboratory, workshops, and sulphate of ammonia and tar plants consisted of mass concrete suitably reinforced with expanded metal or old steel rails in the consolidated made-up ground; and in the case of the large gasholder (the work upon which was in hand at the time of the author's appointment) it had been decided to excavate to the gravel bed, some 7 to 8 ft. deep.

Boreholes indicated that the site of this holder consisted of the best ground, and, generally speaking, the sites of the other sections of plant the worst.

GAS MANUFACTURING PLANT.

The selection of gas manufacturing plant was necessarily influenced by peculiar local conditions, considered in conjunction with and in relation to the merits of the different types of plant.

Arising out of local conditions were the following considerations :

(1) *As to Site.*

The site for the new gas-works is extensive, and the question of maximum gas-making capacity per unit area is not a vital consideration.

(2) *As to the General Character of the Scheme.*

The scheme was for the erection of an entirely new and independent works on a separate site, the proposed coal gas section being the first coal gas section of the new works, and not additional to an existing section.

(3) *As to Coal Supplies.*

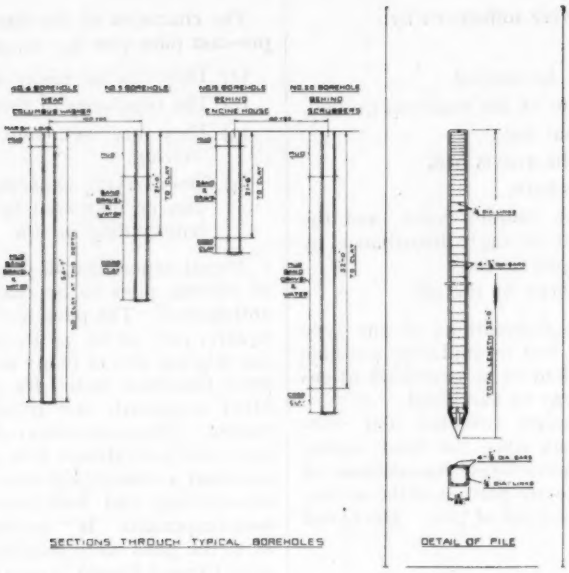
South Wales gas coals are not such good carbonizing coals as the recognized English gas coals, and, furthermore, prolonged experience has revealed considerable variations in the quality of the former.

Our coal-purchasing policy depends upon the relative commercial values of English and Welsh coals; and the capability of the carbonizing plant to attain maximum efficiency when carbonizing the lower-grade coals is an essential consideration.

(4) *As to Market for Gas Coke.*

The local and export market for gas coke is affected by abundant supplies of cheap house coal, steam coal, and anthracite from local coalfields and of locally made coke oven coke.

The gas coke for the local market must be



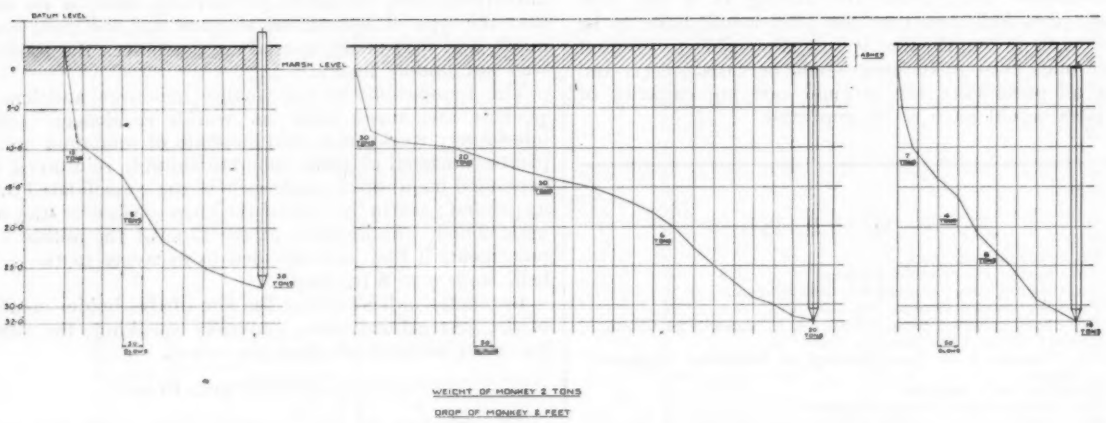


FIG. 2.

large, of good quality, and resembling in appearance that produced in coke ovens.

The coke resulting from a static charge of coal is more suitable for local requirements than that resulting from a dynamic charge.

The equilibrium of supply and demand must be maintained. It can be effectively maintained by adjusting the net amount of coke available for sale by utilizing it for the manufacture of water gas.

These considerations, having due regard to the claims of the different systems of carbonization, resulted in the adoption as manufacturing plant of machine-stoked horizontal retorts and carburetted water gas.

RETORT-HOUSE AND CARBONIZING PLANT.

The retort-house is a brick-panelled steel-frame building, 204 ft. in length by 65 ft. span by 50 ft. to the eaves.

There are fourteen beds of retorts in two benches, each of seven beds, each bed containing ten retorts of D section 24 in. by 18 in. by 23 ft. long. Each retort is capable of carbonizing 18 cwt. charges in 12 hours, or 36 cwt. per diem.

The settings are heated by tubular regenerator furnaces, and each producer is fitted with a step grate, and has a grate area of 0·8 sq. ft. per ton of coal per diem.

Each bench is controlled by two sets of governors from which the gas is taken to a 30-in. diameter foul main running around each of the four sides of the retort-house. A 12-in. diameter branch is provided in this ring main to enable blue water gas to be admitted, should this at any time be desirable.

The retorts are operated by a Drakes combined charging and discharging machine capable of discharging and charging the whole of the 140 retorts in a working shift of eight hours.

The coke is discharged from the retorts by the ram of the Drakes machine into the adjustable tube of the "G.N." hot coke transporter, which delivers the hot coke either to the external quenching bench or into the producer, and the transporter is fitted with a producer lid lifting device which enables the operator to lift, move, and replace the lids without leaving his platform.

SILICA AND FIRECLAY RETORTS.

The opportunity was taken to construct some of the retorts in segmental silica blocks, but unfortunately the experience was not a happy one. After a comparatively short working life the retorts became badly misshaped, the jointing cement disappeared completely, and as the segments were only grooved—*i.e.*, not tongued and grooved—they became displaced by reason of the lack of bond, causing the crown segments to project inwards to such an extent that they fouled the ram-head of the stoking machine, and great difficulty was experienced in discharging the coke.

Further, the bottom corner segments nearest the combustion chamber, about 4 to 5 ft. from each mouthpiece, in the retorts in the fourth tier, showed signs of "holing," the whole mass assuming the structure of a large sponge.

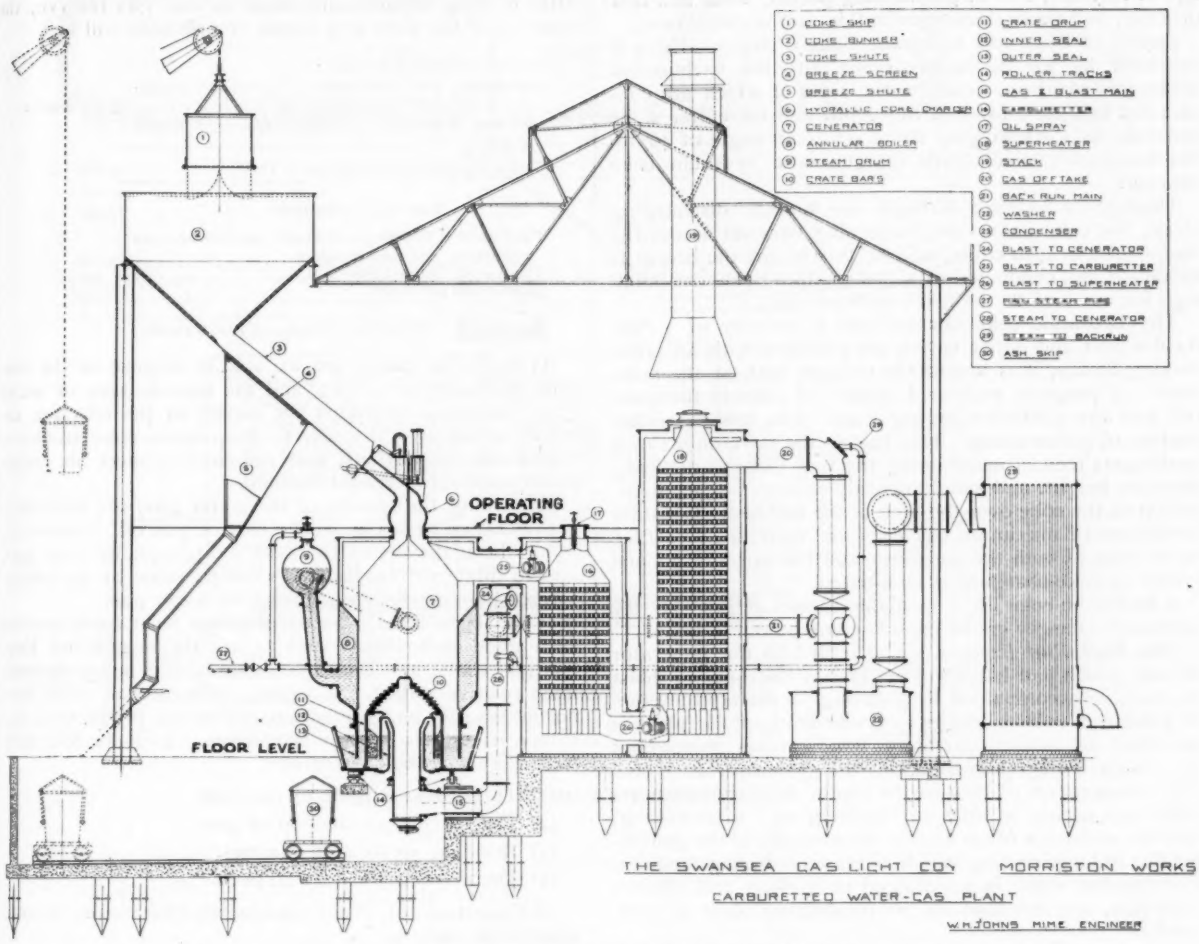


FIG. 3.—SWANSEA GAS LIGHT COMPANY, MORRISTON WORKS.—CARBURETTED WATER GAS PLANT.

These conditions progressed in time through the retorts in the third (or middle) tier, the second tier, and the first (or top) tier. Retorts in the fifth (or bottom) tier did not show this peculiarity.

Ultimately, the silica retorts were replaced by moulded fireclay retorts.

CARBURETTED WATER GAS PLANT.

The carburetted water gas plant comprises two sets :

(1) A new Humphreys & Glasgow plant with self-clinkering generator, having a nominal capacity of 2,250,000 c.ft. per diem.

(2) A Humphreys & Glasgow plant with hand-clinkering generator, having a nominal capacity of 1,250,000 c.ft. per diem.

The latter was originally erected in 1916 at the Company's works at Oystermouth Road, but was dismantled, removed, and re-erected at Morriston Road in the year 1927 by the Company's own labour, in order to act as a reserve plant to the new plant which was erected in 1925.

Fig. 3 shows in detail the self-clinkering plant. Its essential features are :

(1) An annular boiler forming part of the upper portion of the generator and surrounding the clinker-forming portion of the fuel bed, coupled to an independent cylindrical steam and water drum by means of large diameter connections, ensuring ample circulation and easy passage for the water and the steam.

(2) A rotating bottom portion carrying the self-clinkering grate and the inner and outer hydraulic seals. This bottom portion is constructed of heavy castings and carried on roller tracks. A mild-steel plough is carried on the base of the generator, thereby giving a completely automatic and continuous discharge of ash and clinker from the grate.

(3) A mechanical coke charger, consisting of a cast-iron chamber fitted to the top of the generator, with inlet slide valve and a mushroom discharging valve and distributor, hydraulically-operated and interlocked.

(4) Reverse-make apparatus comprising firebrick lined hot-blast and gas connections between the top of the generator and the carburettor, and valved back-run connection between the bottom of the generator and the valved gas offtake conduit from the superheater to the washer. During the back-run the steam is admitted directly into the top of the superheater, and passes up the carburettor and down the generator; blue water gas passing directly to the washer.

The Annular Boiler.—Safety in operation of the vertical annular boiler surrounding the clinker-forming portion of the fuel bed is effected by massive construction of the parts exposed to the fire, and by working at a low pressure.

The steam produced necessarily abstracts heat from the fuel bed, but, on the other hand, this loss of heat is largely counterbalanced by :

(1) Conservation of the heat hitherto lost by radiation and convection from the lower portion of the shell.

(2) Elimination of clinkering periods and the avoidance of the wastage of the fuel bed by combustion under natural draught during clinkering periods.

(3) Reduction of partly-burned coke and of carbon in ash and clinker discharged from the generator.

Rotating Water-Sealed Grate.—The grate effects the regular and continuous discharge of ash and clinker, and consequently a condition of high efficiency is maintained throughout the fuel bed. Prolonged and arduous labour incidental to hand-clinkering is eliminated, as also wast-

age of fuel bed, loss of gas-making period, wear and tear of plant, and general disorganization and uncleanliness.

Supply of Coke and Hydraulic Coke Charger.—Coke is delivered by the locomotive crane into the carburetted water gas overhead bunkers, the sides of which are constructed vertically for half the depth and thereafter slope inwardly to a discharging chute set at an angle of 40° to the horizontal, which feeds the generator hydraulic coke charger.

During its passage through the bunker discharging chute, the coke passes over screening bars set across the mouth of a branch chute, and by this means the breeze is extracted and conducted to a crane skip outside the building, for removal to the main works boilers.

The hydraulic coke charger has a capacity of 3 cwt. As the inlet and outlet valves are provided with an interlocking device, it is impossible to open both at the same time. A properly regulated supply of coke is therefore fed into the generator during each cycle, without interruption of gas-making. This has all the advantages of a continuous feed in maintaining the fuel bed at practically constant height, and simultaneously ensures proper distribution of the coke over the area of the fuel bed. Constant conditions of maximum efficiency are therefore preserved in the tops of both the generator and the carburettor, and labour in coke-charging is eliminated.

A hydraulic coke lift is available should at any time the automatic charger or the outside crane be out of action.

The Back-Run Process.—The return to the generator of heat which had hitherto been lost in the escaping blast products is accompanied by a saving in the consumption of generator coke. The general efficiency of the plant is increased by easier control of temperatures throughout the oil-gasifying chambers and the generator fuel bed. The recuperation of heat in the top of the carburettor results in a saving of time in "lighting-up" after coking, and the avoidance of excessive temperatures in the generator due to long blasting which increase clinkering troubles. The checker work is maintained in a clean and efficient condition, and the load on the condensing plant is lightened.

Complement of Labour.

The labour complement of the retort house and coke handling plant is given in the accompanying table, extended to show the thermal production per man per diem, and the labour cost per therm when carbonizing :

(*a*) All Welsh coals.

(*b*) A 60 : 40 mixture of Welsh and English coals.

(*c*) All English coals.

The water gas plant is operated by two men per shift of eight hours.

Accordingly, when both the coal gas and the carburetted water gas plants are operated at full working capacity, after making suitable allowance for coal gas reserve, the capacity of the plant and labour complement will be :

Coal Gas; 12 Beds of Retorts—

Carbonizing a 60 : 40 mixture of Welsh and English coals—216 tons at 67½ therms per ton	14,580 therms
Carburetted Water Gas; Working Capacity, 2 Million C.Ft.—	
Carburetting to a quality of 450 B.Th.U.	9,000 ,,
Total Gas Production	23,580 ,,
Total number of men per 24 hours, gas-making, coke quenching, and coke handling	26
Therms per man per diem	900
Labour cost per therm	0·14d.

Manufacturing Programme.

At Swansea, rarely are we able to dispose of the current production of coke; and the manufacture of water gas is essential to adjust the supply to the effective demand, or at least in order to keep down coke stocks to reasonable proportions, and sufficient to meet an anticipated seasonal increased demand.

Regarding the quality of the water gas, the additional consideration arises as to the cost of gas oil. Generally, it has been the policy to make a high-quality coal gas, and to dilute to the declared calorific value by an admixture of blue or slightly carburetted water gas.

It has been already stated that the local coals are not such good carbonizing coals as are the recognized English gas coals, and that a coal-purchasing policy depends upon relative commercial values. Commercial value does not necessarily imply quantitative thermal production, but rather cheapness in unit production; and the following factors have to be considered :

(1) The delivered price of the coal.

(2) The thermal production of gas.

(3) Residual yields and qualities.

(4) The markets for residual products.

The purchase of Welsh and/or English coals depends upon these factors.

Tests have revealed that the Welsh coals give yields of gas varying from 50 to 62 therms per ton, whereas when carbonizing English coals 73 therms per ton are obtained.

During the half-year ended Dec. 31, 1927, a 60 : 40 mixture of Welsh and English coals was carbonized, and the average yield of gas was 67½ therms per ton.

In addition to an increased make of gas, the introduction of better-class coals has other practical aspects; and in this regard the Welsh through or unscreened coals which are carbonized at Swansea bear the following characteristics when compared with English coals :

(1) The nature of Welsh coals is more clayey than English coals and the charges are not so even.

Labour Complement of Carbonizing Plant, Therms Made per Man per Diem and Labour Cost per Therm.

Description.	No. of Men per Shift.		Shifts per Diem, 12-Hour Charging.	No. of Men per Diem				Therms Made per Man per Diem and Labour Costs per Therm.											
								Carbonizing Welsh Coals.				Carbonizing English Coals.				Carbonizing a Mixture 60 : 40 Welsh and English.			
								6 Beds.		12 Beds.		6 Beds.		12 Beds.		6 Beds.		12 Beds.	
	6 Beds.	7/12 Beds.		6 Beds.	Tons Coal Carbonized per Man per Diem.	12 Beds.	Tons Coal Carbonized per Man per Diem.	Therms per Man per Diem.	Labour Cost per Therm. Pence.	Therms per Man per Diem.	Labour Cost per Therm. Pence.	Therms per Man per Diem.	Labour Cost per Therm. Pence.	Therms per Man per Diem.	Labour Cost per Therm. Pence.	Therms per Man per Diem.	Labour Cost per Therm. Pence.	Therms per Man per Diem.	Labour Cost per Therm. Pence.
Retort house—																			
Cellarmen . . .	1	1	3⅜	3	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..
Charging side . .	2	2	2	4	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..
Discharging side . .	2	3	2	4	..	6	..	..	..	..	..	..	..	..	..	..	..	..	..
	5	6	..	11	10	13	17	520	0·24	880	0·14	700	0·17	1200	0·10	675	0·18	1140	0·11
Coke handling—																			
Quenching . . .	1	1	2	2	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..
Crane	1	1	2	2	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..
	7	8	..	15	7	17	13	..	..	..	..	..	..	..	..	..	..	..	..
Foremen	1	1	3	3	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	8	9	..	18	6	20	11	317	0·39	570	0·22	430	0·28	780	0·16	413	0·30	740	0·17

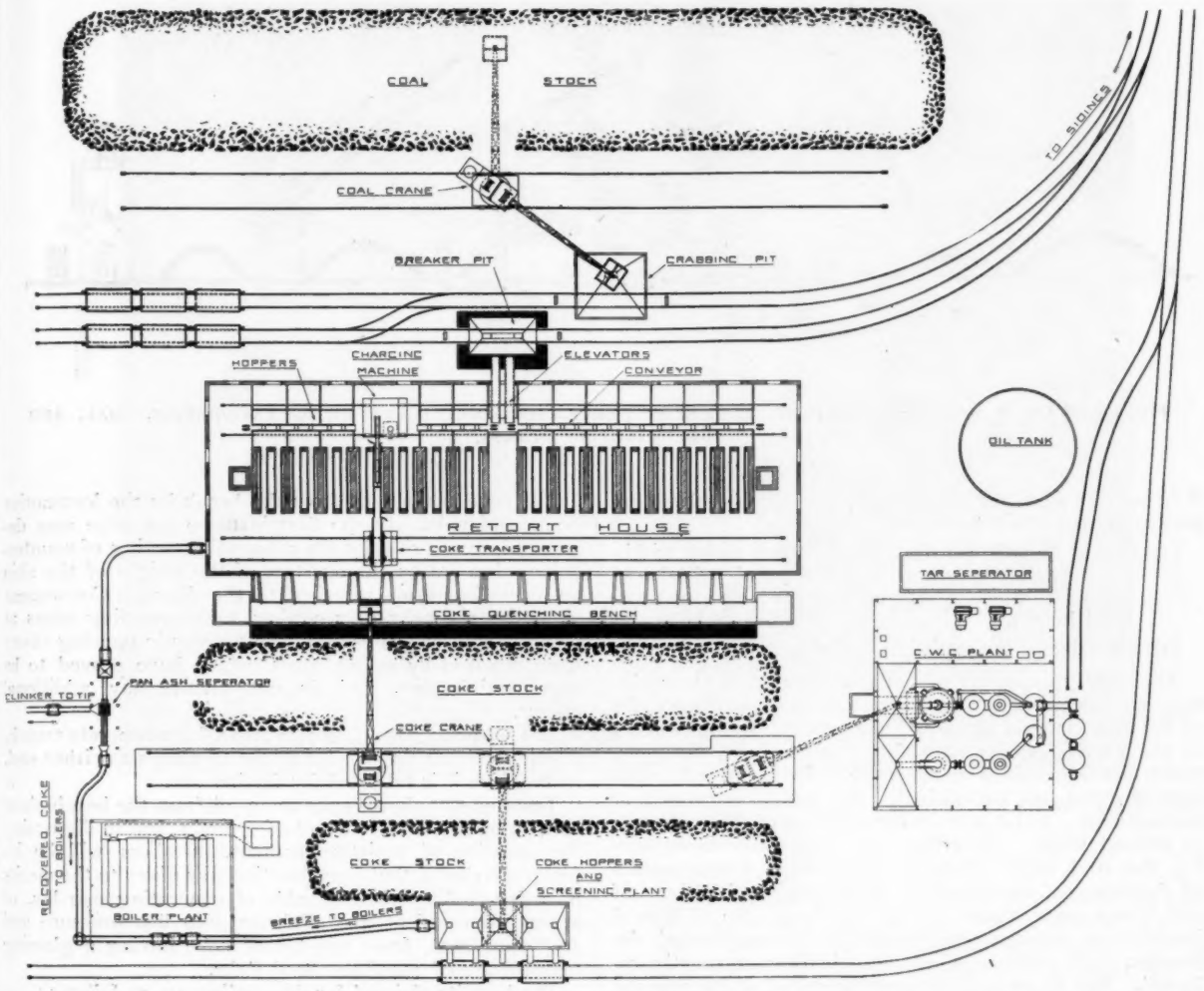


FIG. 4.—SWANSEA GAS LIGHT COMPANY, MORRISTON WORKS.—BLOCK PLAN OF CARBONIZING, COAL AND COKE HANDLING PLANT.

(2) With Welsh coals, higher temperatures are necessary for carbonization, and even so there is a distinct limitation to the quality of the gas. Consequently, it is necessary to use more oil in the water gas plant in order to maintain a mixed gas of statutory quality.

(3) Welsh coals vary considerably in quality.

(4) Welsh coals contain a higher proportion of ash, which reflects in :

(*a*) A high ash content of the coke, and consequently a poorer coke for sale and for water gas purposes.

(*b*) Greater clinker formation in the producers, longer periods for clinkering, and more arduous labour; and, incidentally, a loss of coke in maintaining clean producers.

(5) Generally, the sulphur content of Welsh coals is higher. Therefore, purification charges are heavier.

(6) For equal production of coal gas therms a greater quantity of Welsh coal would be necessary. Therefore, more beds would have to be worked, and repair and maintenance charges would be heavier.

(7) The retorts give a longer working life when carbonizing the better-class coals.

It has been ascertained that the better conditions in the retort house consequent upon the introduction of the English coals has tended to give a more than proportionate increase in the production of gas therms per average ton of coal.

Coal Gas Condensers.

The coal gas condensers are of the water-cooled horizontal cast-iron tube type, made by Messrs. W. C. Holmes & Co., Ltd. The flow of gas may be reversed. A high-velocity water travel reduces to the minimum silt and other solid matter deposits. The surplus water is conducted to the main works boilers.

Washing and Scrubbing Plant.

The coal gas, ammonia, and naphthalene rotary washers are erected in one group. The gas connections are so arranged that naphthalene extraction is conducted after purification. A Livesey washer is employed for the extraction of naphthalene from the water gas. The process of naphthalene extraction has been so successful that naphthalene complaints have been eliminated entirely.

Mechanical Equipment.

The mechanical equipment incidental to coal and coke handling is shown in block plan and cross-sectional elevation in figs. 4 and 5.

Coal Stocking.

The necessity of maintaining adequate stocks of coal, and of being able to remove and replenish such stocks rapidly and cheaply, has been accentuated by the relative frequency of post-war industrial difficulties; and an efficient coal stocking system is an essential adjunct to every works of large and moderate size. The elements of such a system are :

(1) Rapidity in execution.

(2) Simplicity in design and lay-out.

(3) Little mechanical wear, and consequently low maintenance costs.

(4) Effective relationship between capital cost and working capacity.

The system at Morriston comprises :

(1) A locomotive crane provided with a grab and running on a track of 8 ft. gauge.

(2) A ferro-concrete grabbing pit equipped with hydraulic wagon tipplers.

(3) An open yard heap.

The crane is fitted with two rope barrels which enable

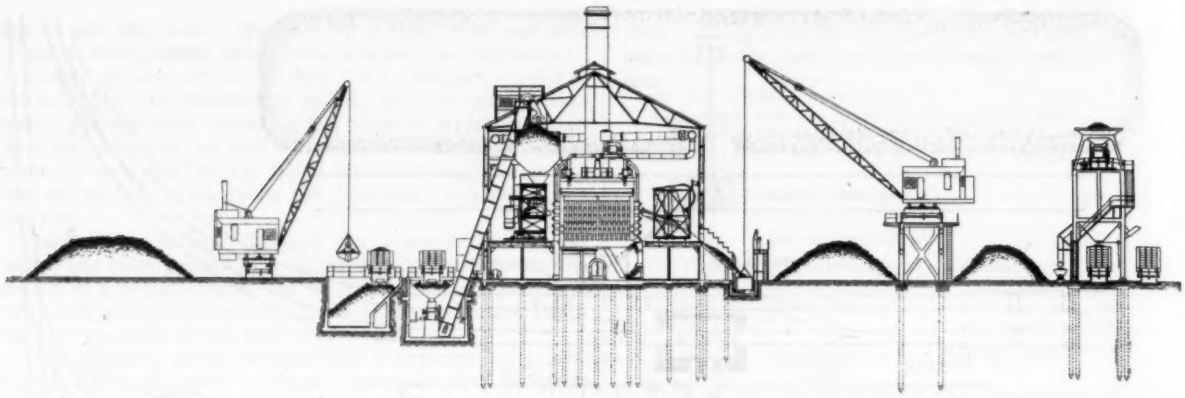


FIG 8.—SWANSEA GAS LIGHT COMPANY, MORRISTON WORKS.—SECTIONAL ELEVATION OF CARBONIZING, COAL, AND COKE HANDLING PLANTS.

it to operate four-rope grabs. This double barrel system possesses two distinct features:

(1) The grab may be discharged at any point within the range of the lift without the use of a discharging ring, which would only empty the grab at a fixed height.

(2) Spinning of the grab is avoided.

The average capacity of the grab is 2 tons; 20 cycles may be completed in one hour, and the hourly capacity of the crane is thus 40 tons. The maximum requirements of the retort house are 240 tons on 12-hour charging, which can be provided by the crane in six hours at a labour cost of 0·75d. per ton of coal. The system is capable of extended use; and it permits the stocking of different coals in distinct heaps. Its utility was most pronounced during the coal strike of 1926, when single consignments of foreign coal amounted to 3000 tons, the delivery of which was concentrated over a few days. No additional labour was necessary to handle such concentrated deliveries, and traffic was in every instance promptly released. But in normal circumstances coal stock removal and replenishment are operations which are conducted neither continuously nor regularly. At Morriston such operations have been conveniently combined with the usual duties of the two coal-elevator plant attendants in their normal working day; the type of plant and general arrangement of the scheme making this possible.

COAL-BREAKERS AND ELEVATORS.

Two four-roll coal-breakers, provided with an adjustable rate of feed, deliver the coal into twin elevator boots which feed two enclosed elevators each capable of dealing with 60 tons of coal per hour.

RETORT HOUSE MACHINERY.

The author has already referred to the essential mechanical equipment of the retort house. The Drakes combined charging and discharging machine and the "G.N." hot coke transporter are to-day so well known that detailed description is not necessary. The former ensures rapid charging and discharging of the retorts, and the latter economic handling of coke, direct and smooth passage of hot coke to the external quenching bench, and automatic feeding of producers. Satisfactory working conditions are a pleasing feature of the use of both machines.

COKE QUENCHING.

The coke is delivered by gravity from the tube of the "G.N." hot coke transporter to a ferro-concrete quenching bench constructed the whole length of the retort house, sloping at an angle of 40° to the horizontal, and supported on the one side by the retort house framework and on the other side by ferro-concrete piers.

The bench is divided by dwarf walls into tapering bays, one bay for each bed of retorts. Originally, the bays were lined by acid-resisting bricks, but the constant and sudden changes in temperature incidental to coke quenching resulted in the cracking and wearing of the bricks to such an extent that ultimately it was decided to line the bays with cast-iron plates 2 in. in thickness. These plates have proved to be entirely satisfactory.

The coke is removed from the bench by the locomotive crane and skip. In the first instance the coke was delivered into the skip by the automatic opening of counterbalanced doors by the exertion of the weight of the skip on operating arms attached to the doors. Consequent upon the necessity of renewing such operating arms at frequent intervals, however, the automatic opening doors were replaced by swing doors, which have proved to be more satisfactory, and do not involve any additional labour.

The quenching bench drains into a ferro-concrete trench, which conducts the surplus water to sumps at either end, from which it is returned for further use.

Tests on samples of coke removed from the bench show an average moisture content of 7 p.ct.; and in discussing the question of moisture content, members will be interested to know that consideration was given to the merits of a dry cooling plant capable of generating 920 lbs. of steam from and at 212° Fahr. at 150 lbs. pressure and 100° superheat, from one ton of coke having a glowing temperature of 2000° to 1800° Fahr.

The benefits claimed for dry cooling are as follows:

(1) A reduction in the proportion of breeze.

(2) A reduction in boiler capacity and consequent savings in expenditure on boiler plant, in water consumption, and in fuel.

(3) Elimination of expenditure on water for quenching.

(4) A better coke for consumers.

While such advantages were appreciated, and the process was regarded in principle favourably, particularly as the coke handling system would not have had to be extended, the dry cooling plant was not adopted principally because:

(1) The necessity of installing boilers could not be entirely dispensed with.

(2) The production of steam in central boilers would be supplemented by the production of steam in the carburetted water gas annular boiler.

(3) The capital cost was heavy, and not justified by the size of the works.

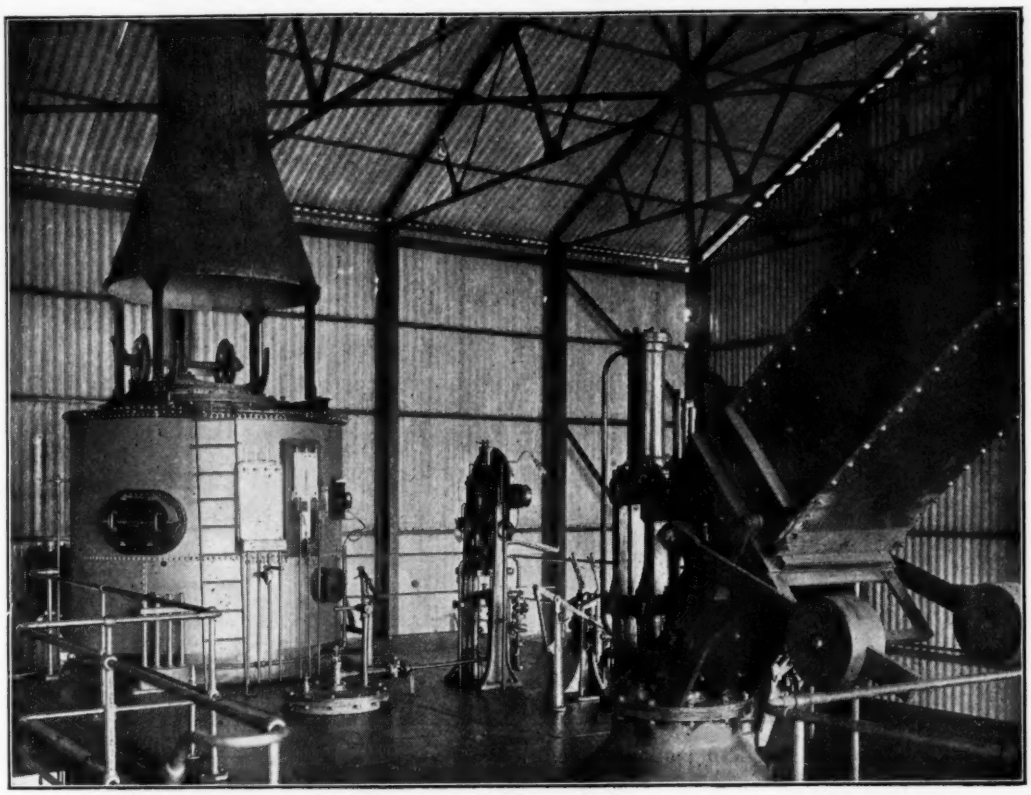
The advantages of a dry cooling plant may be associated with the advantages accruing to large-scale production; and when the works are extended the installation of such a plant with waste-heat boiler may be reasonably considered.

EXTERNAL COKE TRANSPORT.

In designing the coke transporting system, the following requirements were considered:

(1) Transport of coke from the quenching bench to:
- (*a*) Storage hoppers.
- (*b*) Yard heap.
- (*c*) Carburetted water gas plant.

(2) From yard heap to:
- (*a*) Storage hoppers.
- (*b*) Carburetted water gas plant.
- (*c*) Railway trucks.



C.W.G. PLANT, SHOWING OPERATING FLOOR WITH COKE CHUTE AND HYDRAULIC CHARGER ON RIGHT, OPERATING GEAR AND SUPERHEATER ON LEFT.

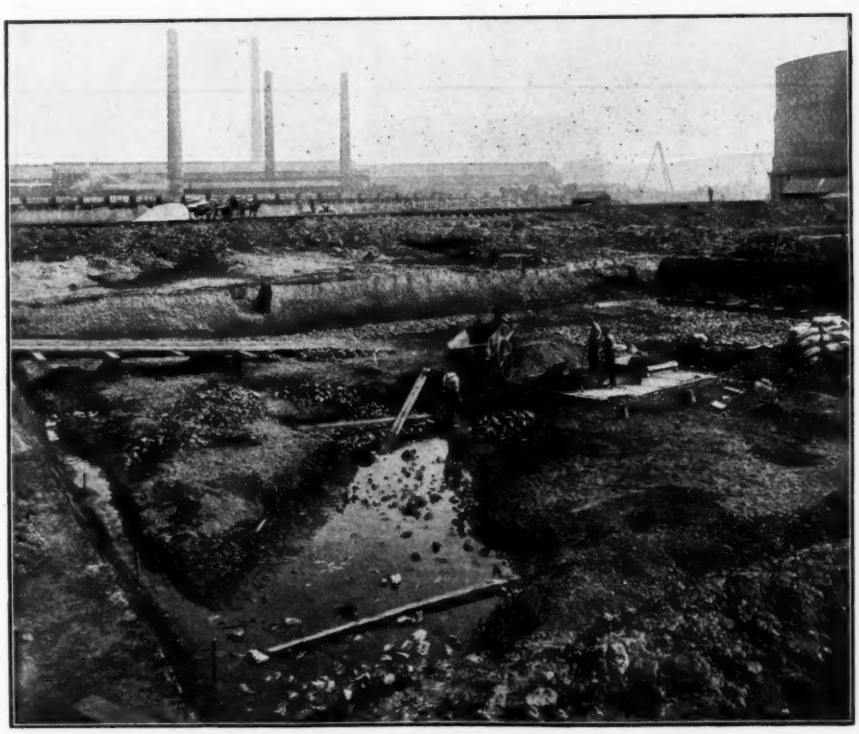
(3) Transport of pan-ash from retort house and carburetted water gas plant to the pan-ash washing plant.

(4) Transport of breeze to boilers.

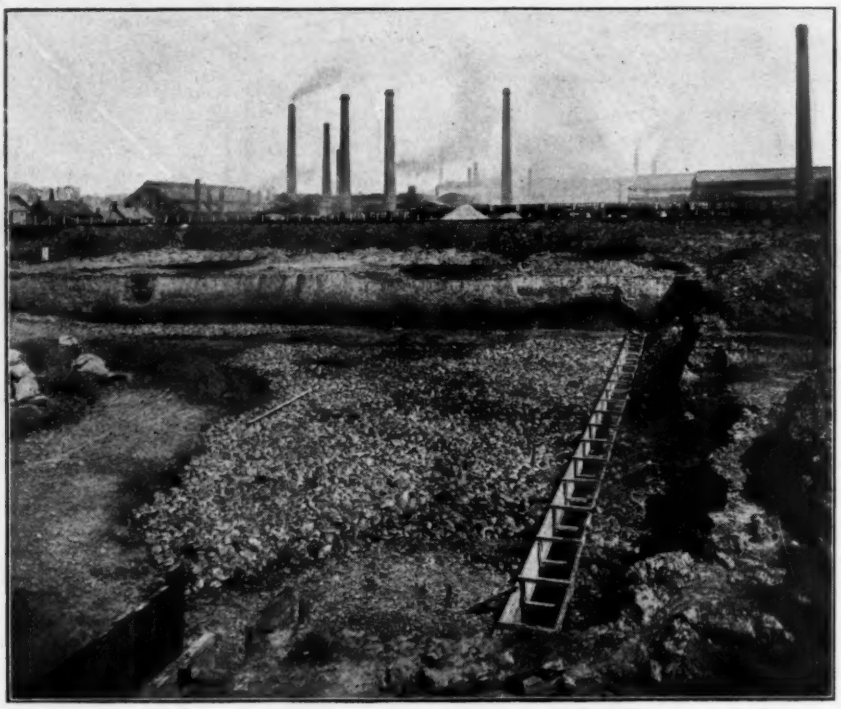
With the object of combining these duties in one reliable unit of plant, it was decided to adopt a locomotive crane travelling on a gantry.

The crane has a gauge of 12 ft., is similar in design and capacity to the coal crane, and is provided with both grabs and skips. Fully loaded, its total weight is 60 tons, while it exerts a load of 43½ tons on the wheels on one side when the jib is fully extended to a radius of 55 ft. on that side.

The gantry stands 18 ft. above ground level, is 232 ft. 6 in. long and 18 ft. 6 in. wide, including a side-walk overhang of 4 ft. 6 in. It is constructed in ferro-concrete, the platform being supported by stanchions



EXCAVATIONS FOR TAR AND LIQUOR WELL, SHOWING LARGE MUD POCKET IN FOREGROUND.



EXCAVATION FOR TAR AND LIQUOR WELL, SHOWING LARGE MUD POCKET FILLED IN WITH HARD CORE.

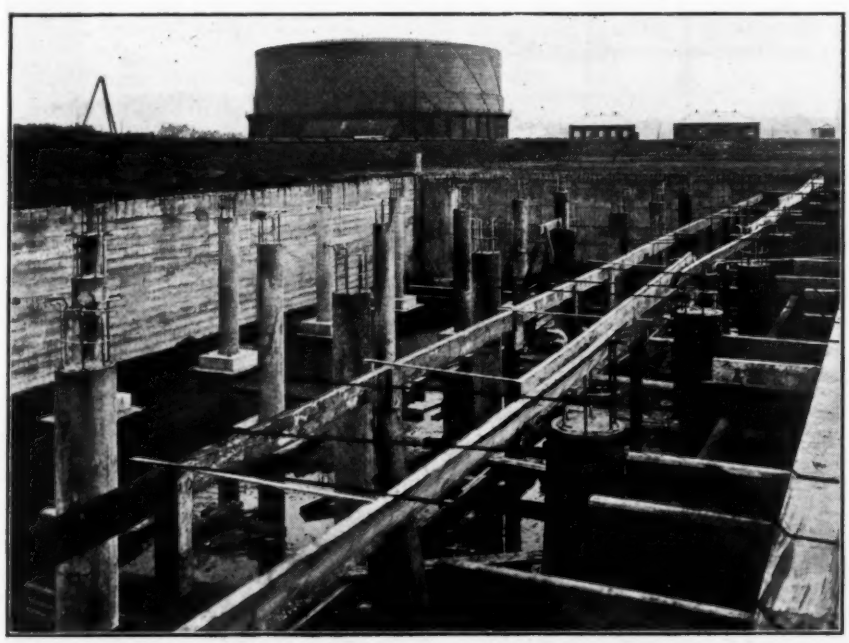
15 in. square braced longitudinally, laterally, and transversely, each stanchion being carried by and constructed monolithic with a 15 in. square pile. The superstructure is so designed that the weight of the crane in any position is distributed over as many foundation piles as possible. The crane is sufficiently large to meet the requirements of a second retort house; and the gantry is capable of extension for this purpose.

Coke Screening and Storage.

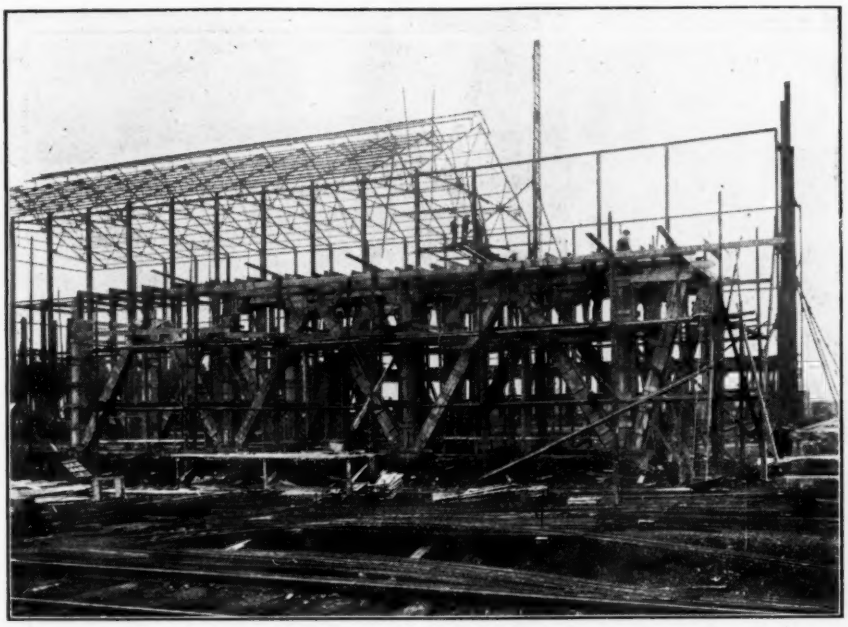
An overhead receiving hopper delivers the coke to a cascade screen which diverts the coke into two outer compartments of the ferro-concrete storage hoppers, and the breeze to an inner compartment. The hoppers are provided with suitable chutes for loading railway trucks, works wagons, and road vehicles.

Engine House and Power Plant.

The engine house is shown in block plan (fig. 6). It is situated centrally with the present coal gas section, with the site of the section coal gas section, and with the present, and all future, carburetted water gas sections. It is designed to accommodate the whole of the electric generating plant and exhausters for these sections, and also the steam-driven gas compressors which are necessary to feed the holders at the distributing station at Oystermouth Road, the tar and liquor pumps, oxygen pump, for purification purposes, and foremen's offices.

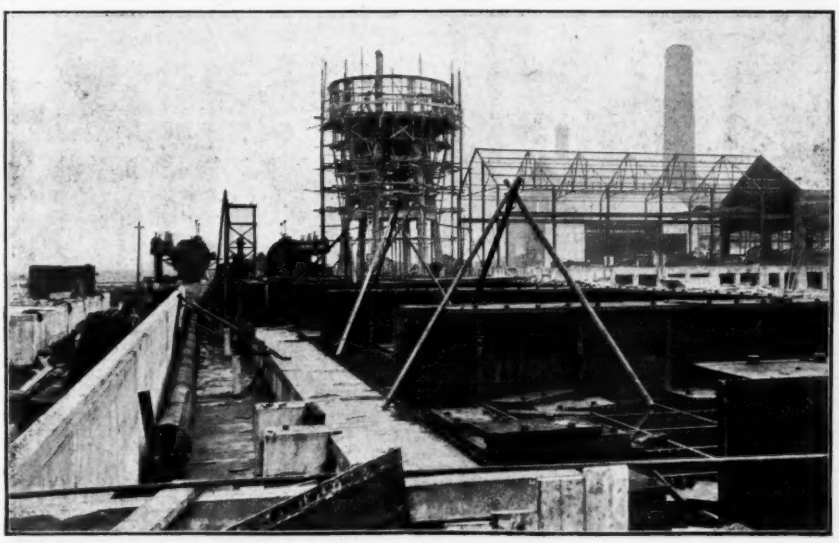


TAR AND LIQUOR WELL IN COURSE OF CONSTRUCTION. No. 5 HOLDER, GOVERNOR HOUSE, AND LABORATORY IN BACKGROUND.



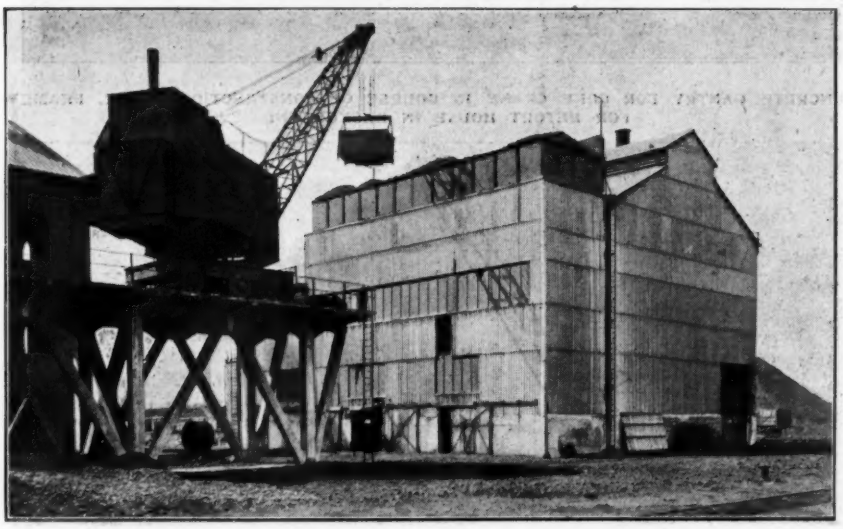
FERRO-CONCRETE GANTRY FOR COKE CRANE IN COURSE OF CONSTRUCTION. STEEL FRAMEWORK FOR RETORT HOUSE IN BACKGROUND.

DISCHARGING SIDE OF RETORT HOUSE SHOWING COKE BENCH AND QUENCHING PLATFORM.

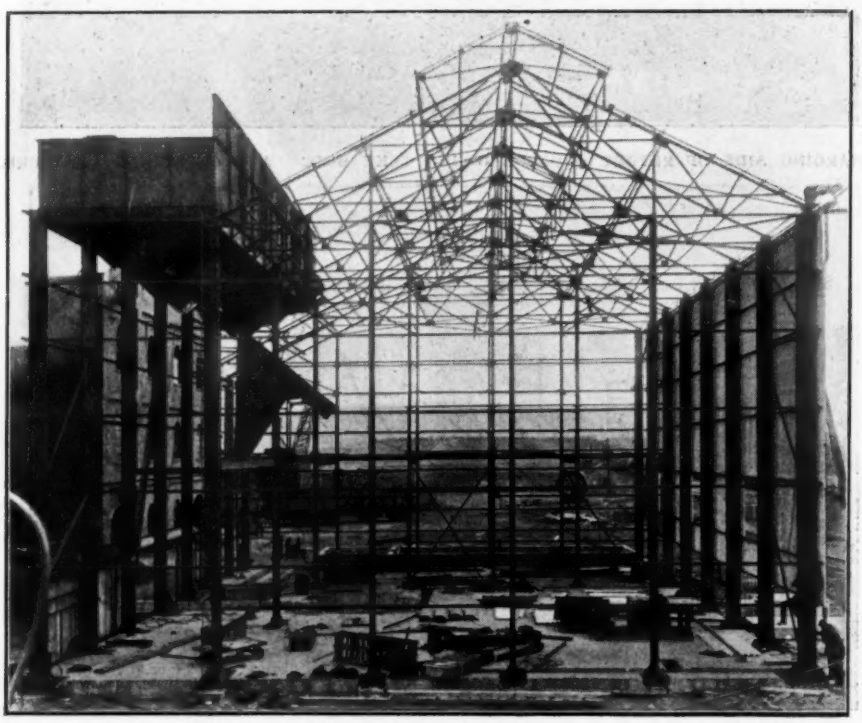


COAL GAS PURIFIERS IN COURSE OF CONSTRUCTION. ROTARY WASHERS, WATER TOWER, AND ENGINE HOUSE BEHIND, RETORT HOUSE AND BOILER HOUSE IN BACKGROUND.

VIEW SHOWING GABLE END OF C.W.G. PLANT AND COKE CRANE FEEDING C.W.G. COKE BUNKER. OIL STORAGE TANK IN FOREGROUND, AND RELIEF HOLDER IN BACKGROUND. RETORT HOUSE ON THE RIGHT WITH COAL GRABBING CRANE.



VIEW SHOWING C.W.G. BUILDING, OVERHEAD BUNKER, COKE CRANE ON FERRO-CONCRETE GANTRY. RETORT HOUSE ON LEFT.



C.W.G. PLANT, SHOWING STEEL FRAME BUILDING AND COKE BUNKER.

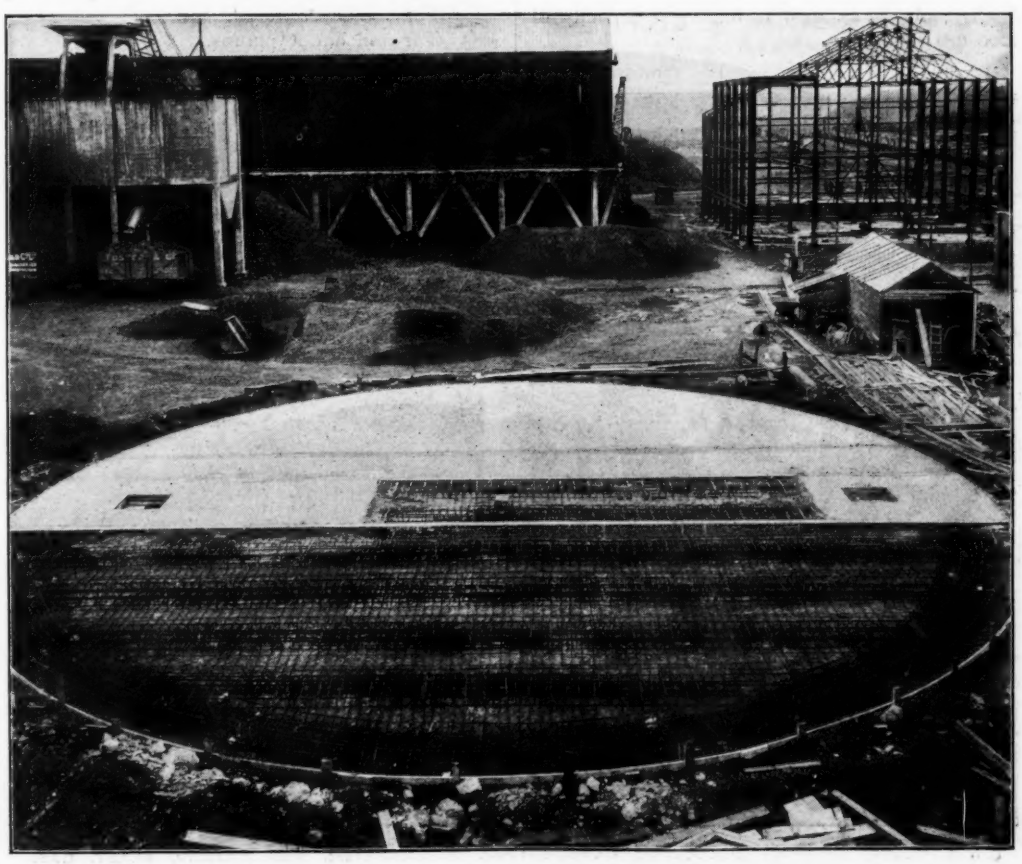
C.W.G. PLANT, SHOWING OPERATING FLOOR WITH COKE CHUTE AND HYDRAULIC CHARGER ON LEFT, SUPERHEATER AND OPERATING GEAR ON RIGHT.

Such centralization of important machinery is accompanied by the following real economies:

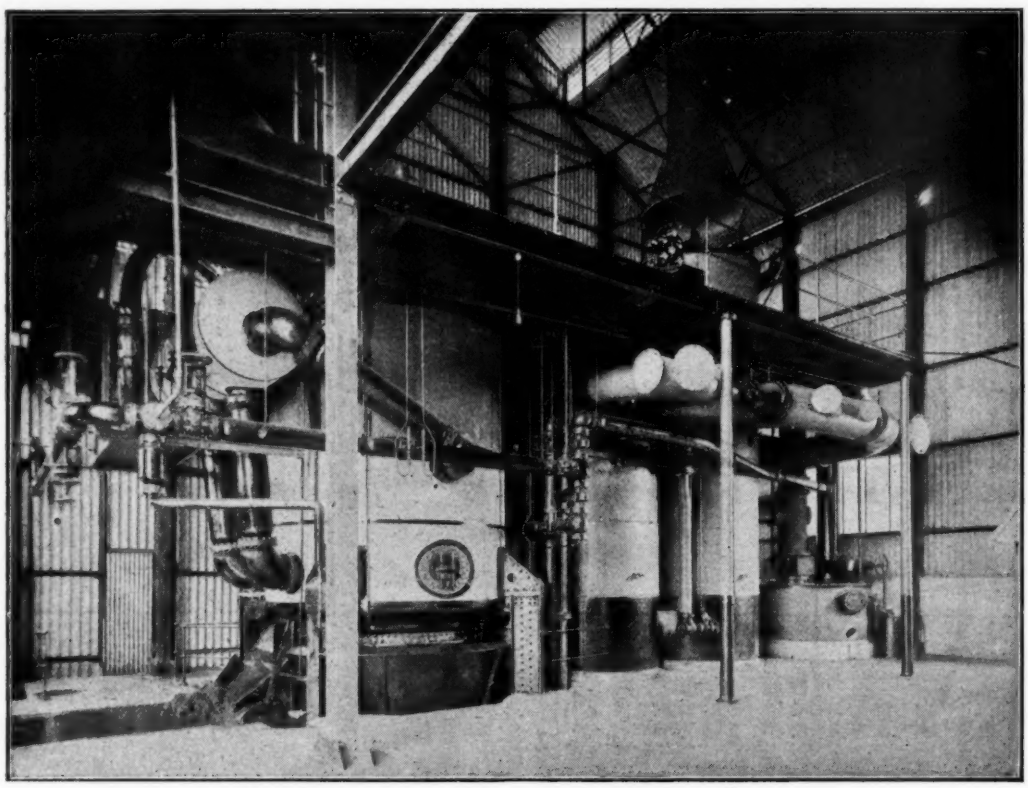
(1) In capital cost.
Economy in lay-out, in building construction, reserve plant, and steam connections.

(2) In organization.
Centralized control facilitates better supervision.

(3) In maintenance and working.
Economy in steam consumption, oil consumption, and labour.



C.W.G. PLANT, SHOWING HOLDER REINFORCEMENT IN CONCRETE SLAB.



C.W.G. PLANT, SHOWING GENERATOR WITH STEAM DRUM ON LEFT, ROTARY GRATE AND CLINKER DISCHARGE, CARBURETTOR, SUPERHEATER, AND WASHER.

The plant already installed is attended by one man and a youth per shift, and comprises :

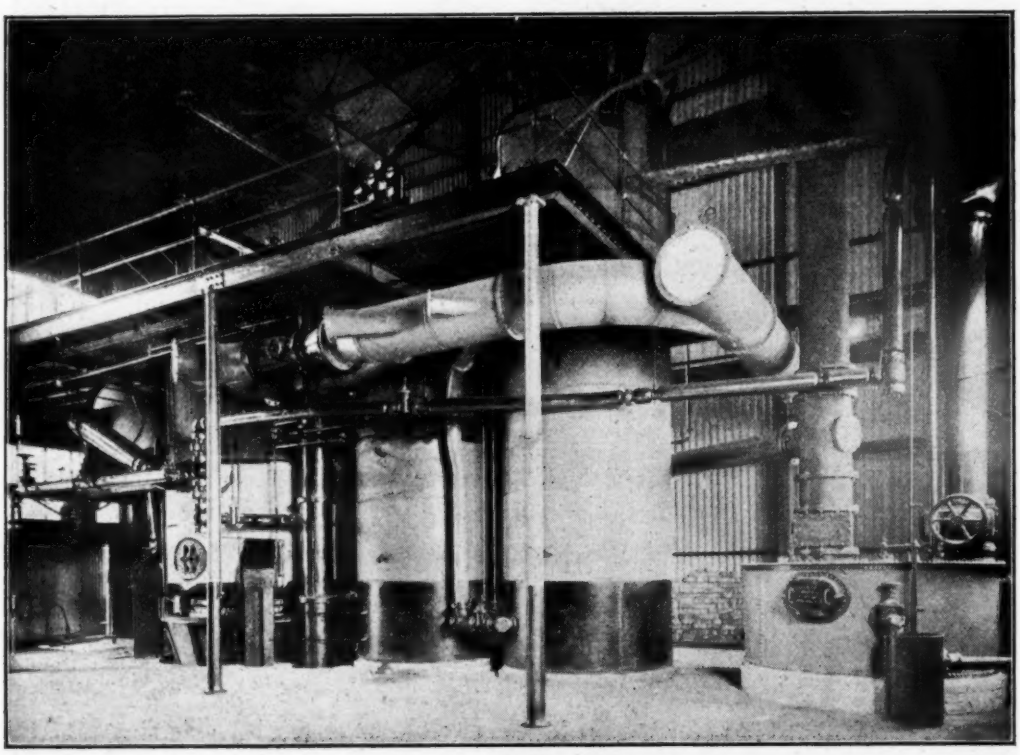
(1) Three electric generators, two having a capacity of 200 KW. each for day load (one being a spare set), and one having a capacity of 70 KW. for night load.

(2) Duplicate coal gas exhausters having a capacity of 150,000 c.ft. per hour.

(3) One carburetted water gas exhauster having a capacity of 100,000 c.ft. per hour. The connections of the exhausters are so arranged that the coal gas and the carburetted water gas units are interchangeable in duty.

(4) Duplicate gas compressors each having a capacity of 100,000 c.ft. per hour.

(5) Tar and liquor pumps.



C.W.G. PLANT, SHOWING GENERATOR, CARBURETTOR, SUPERHEATER, AND WASHER, BLAST, GAS, AND STEAM MAINS.

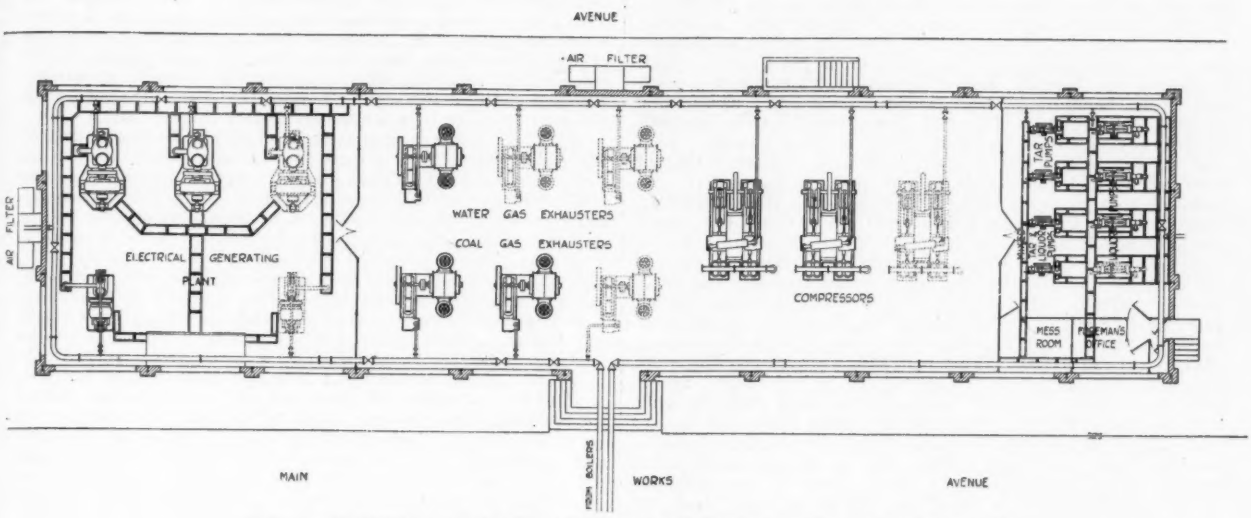
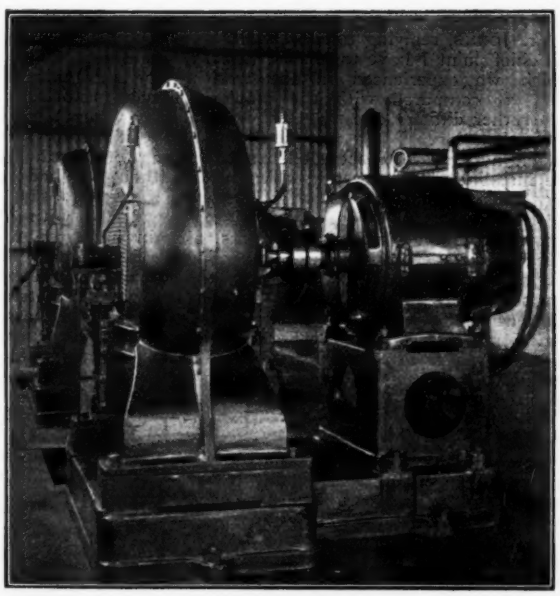
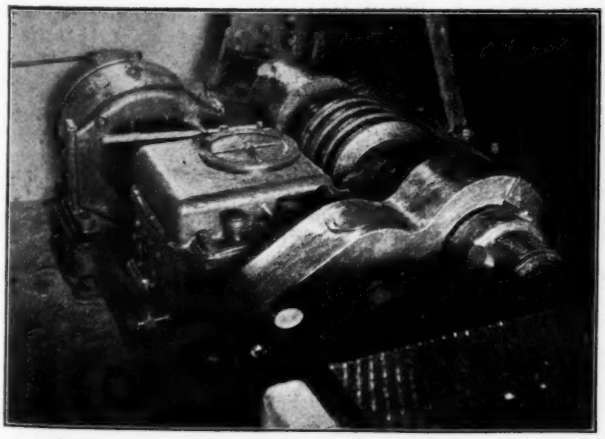


FIG. 6.—SWANSEA GAS LIGHT COMPANY, MORRISTON WORKS.—ENGINE HOUSE.

The application of electric motive power is very wide, and in designing the various distributive units an effort was made to standardize equipment in such a manner as to promote the greatest interchangeability consistent with economy in capital cost and maximum efficiency in working.



C.W.G. Plant.—75 H.P. Motor Blowers.



C.W.G. Plant.—Motor, Gear Box, and Worm Drive for Rotary Grate.

The following plant is electrically controlled:

Capstans, hydraulic tippler pumps, coal breakers, elevators, and conveyors.

The retort charging and discharging machine and the "G.N." hot coke transporter (separate motors for each action).

The coke bench water circulating pumps; the coke screening plant.

The engine house ventilating fans.

The portable conveyor.

The sulphate of ammonia centrifugal drier and elevator.

The carburetted water gas turbo-blowers and the self-clinkering grate.

The fittings shop machine tools and the smithy fan.

The pan-ash washing plant.

MAINTENANCE COSTS.

In view of the short period the works have been in operation the author has not included any data as to maintenance costs; but such costs have been extremely low, and there is every indication that this satisfactory feature will continue.

CONCLUSION.

The author has purposely omitted reference to many sections of the works which were described in his Presidential Address to the Wales and Monmouthshire District Institution of Gas Engineers and Managers, and he trusts that members of the Institution of Gas Engineers will not consequently regard the present paper as incomplete.

Discussion.

The PRESIDENT: We have had a very interesting paper from Mr. Johns in regard to the Morriston Works, and I should like to thank him very much for his great contribution. I know the Morriston Works well; I have been there several times with him, and I saw them on their completion. There is one thing I should like to say about the foundational work. In the Bristol Channel we have a very heavy rise and fall of tide; the soil that we get along the coast-line to the south of the mountains is a very difficult soil, and, as Mr. Johns has said, it contains pockets. I have had a good deal of experience with it, and have had to carry out foundations which have been anything, in the case of one building, from 18 to 50 ft. deep. We have had to go down that distance before we have reached solid ground.

Lieut.-Colonel W. M. CARR, M.C. (Stretford): There are one or two points which I wish to raise, and which interested me particularly on reading Mr. Johns' very excellent contribution. I was very interested to make a comparison of the figures he gave of yield of therms per man per diem with figures that I have obtained on a plant which is somewhat similar, but which has entirely different handling plant. Whereas at the Morriston Works cranes are used for the handling of both coal and coke, at Stretford I am using telphers for picking up the coal direct and delivering to the push-plate conveyors, and also for carrying out the coke only to the quenching bench. I have excluded the men handling the coal to the retort house, because apparently they are excluded from the figures given by Mr. Johns. The actual comparison shows that with twelve beds in operation at Morriston there is a yield of 570 therms

per man per diem when carbonizing Welsh coal, and 780 therms per man per diem when carbonizing English coals. At Stretford our average yield per man per diem, excluding coal handling men, with twelve beds in operation, is 724 therms, which is slightly less than Mr. Johns' figures, which relate to a plant with crane handling. There is one other point I should like to raise. Mr. Johns said that he dismantled his silica segmental retorts and put in moulded retorts in their places. Last year, at the Institution meeting, I think I mentioned that at Stretford we had had trouble with the silica segmental retorts, particularly with the opening of the joints on the combustion chamber side. We repaired these, and put in shield tiles under the joint which had given the principal trouble, and some of those beds, due to the means we have been taking to prevent the joint opening and the jointing material dropping out, have worked perfectly satisfactorily for the past eighteen months. The result of putting in the shield tile, however, on the combustion chamber side has been to lessen slightly the heating efficiency of the setting. That is to say, we want slightly more fuel, but we have had no further trouble with the silica, and it looks as though the retorts are going to stand perfectly well. I think it is only fair to say that the silica horizontal retorts no doubt are perfectly good, and it does appear that the troubles we have had have been mainly due to structural defects—possibly some trouble has been due to jointing material, but it has been due mainly to structural defects—which I think we shall now overcome. I should like to express my thanks to Mr. Johns for his very valuable contribution.

Mr. H. J. TOOGOOD (Elland): Touching on the question of silica, I note Mr. Johns says that the jointing cement disappeared completely. I should like to ask if that is what Mr. Johns considered was the cause of the trouble with the silica retorts. I should also like to ask if the silica jointing cement had any fireclay introduced into it.

Mr. R. E. GIBSON (Liverpool): I think we all sympathize with Mr. Johns in the troublesome foundation work that he has had to undertake. At Garston we were fortunate in having solid rock to build upon, and that made our work very much easier. I was very sorry to read of Mr. Johns' difficulty with regard to the silica. We have had difficulties at Liverpool with the silica material, but we are hoping that we have overcome those difficulties. We have not given up using silica, and at the present time we are doing three periods of eight hours with horizontal retorts, carbonizing 45 cwt. of coal per 24 hours, which I think is a very remarkable achievement. If Mr. Johns is doing twelve hours' duration, two periods, and ho some day re-sets in silica, I think possibly he may be able to increase the output of his bench by 50 p.ct. The system of handling coal and coke by means of cranes is one with which I entirely agree. We have similar systems working at Liverpool, at very low cost, and with a very small amount of labour. Mr. Johns has installed the latest system of Humphreys & Glasgow water gas plant. We have recently installed at Garston two sets of this kind, and they are working perfectly; they are automatically controlled, and the labour costs are remarkably low. Mr. Johns has remarked that the cost per therm of water gas might be higher than that of coal gas. Our experience at the present time is that the cost of producing carburetted water gas is less than that of producing coal gas. Naturally, I was very pleased to hear Mr. Johns' remarks about the "G. N." machine. The first one was put in at Liverpool. Since its installation improvements have been made, and Mr. Johns has had the advantage of those improvements, but the old machine is still working very well and is giving no trouble, and the cost of renewals is very small indeed. I should like to thank Mr. Johns very much for his paper, to which I have listened with very great interest.

Mr. W. G. S. CRANMER (Willenhall): Mr. Johns said he only employed one fitter and one electrician; and I should like to ask him if they are employed for the repairs on the whole of the works or simply one section of the plant. If he means that only the fitter and the electrician are required for work on the whole of the plant, then I would suggest that in a year or two's time Mr. Johns might have rather a different story to tell us, for the plant is entirely new, and, therefore, the amount of repairs required is very much less now than it will be later on. In a works very much smaller than that of Mr. Johns, I am afraid I cannot manage with that number. We employ more, but we make many of the parts ourselves, and possibly this entails more fitting work on the premises. I know that in many cases engineers buy their parts from the makers of the plant and simply drop them into position, which, of course, makes a difference in the amount of work to be done by fitters. I should like to ask Mr. Johns if the fitter and electrician he mentioned are employed on the whole of the plant or simply on the retort house plant.

The PRESIDENT: I should like to call on Mr. Leather, because there is a question about refractories on which he might be able to throw some light.

Mr. J. P. LEATHER: I should like to hear Mr. Johns' answer to the question which was put as to the jointing cement. The question of cement is one which the Refactories Committee are going to consider. The word "cement" rather implies that something rather special was used, and the fault might easily be in the constitution of the cement. There is a good number of people who sell cement for various purposes. Whether it is that some of these proprietary articles have been used, I do not know, but perhaps Mr. Johns could tell us what the constitution of the cement was, because he talks of some portion of the silica retorts becoming like a sponge, and from my experience I should say that that rather implies that there has been some effect on the silica by some material other than the silica itself.

Mr. F. P. TARRATT (Newcastle-on-Tyne): The point made by Mr. Johns about silica retorts and the discarding of silica retorts in favour of clay raises a very important question. I have had experience with silica retorts since 1921. The first installation, when I adopted the 24 in. by 18 in. retorts, we put in 24 beds; there being ten in each bed. They went in as clay. The next thing we started with was siliceous material—*i.e.*, semi-siliceous retorts—and they turned out to be very successful. My next efforts were with three or four varieties of pure silica, and they have been very successful indeed, and are still working to-day. Only in one bed did we have trouble with the opening of the joints, and I think it was due to faulty workmanship. These certainly did give us a little trouble, but they worked for a considerable time, and very satisfactorily. But I have rather changed my mind with regard to the 24 in. by 18 in. retorts. I think the 24 in. by 18 in. is a very ugly section indeed, and I am strongly of the opinion that, if you reduce the section, you will be able to carbonize as much coal as you can in a 24 in. by 18 in. retort. This was clearly brought out by Mr. Stephen Hay, of the Gas Light and Coke Company, in his recent paper. I do not think the 24 in. by 18 in. is a suitable section; and it is certainly a very weak one. We are this year putting in 24 in. by 16 in. retorts to carbonize Durham coal, and we shall certainly get at least 250,000 c.ft. of gas (say) 560 B.Th.U. calorific value out of Durham coal, in a setting of ten retorts, per day—and Durham coal needs some carbonizing.

The PRESIDENT: I can see the difficulty of raising a lot of questions on Mr. Johns' paper, because it is an account of constructive work; and, as we have a good deal to do, I will ask Mr. Johns if he will be good enough to reply to the questions that have been put to him.

Mr. JOHNS, replying to the discussion, said: It appears that the chief point I have to answer is with regard to the defects which we experienced in the working of the silica retorts as compared with the moulded fireclay retorts. It is a rather difficult question for me to answer without giving an explanation. When we prepared our specifications I felt I could not take the responsibility of specifying for the whole of the installation to be set in silica retorts, though I had had very considerable experience, if I may be allowed to say so, in the working of silica. When I was connected with Mr. Bywaters at the Saltley Gas-Works, Birmingham, we used silica to a very large extent. We adopted the ordinary fireclay sections, Stourbridge material, in the bottom of the retorts, and set the crown of the retorts in silica and similar material. Also, at Sheffield, I found on my arrival that my predecessor, Mr. Morrison, was a great believer in the working of segmental silica retorts, and by so doing was able to keep down his maintenance costs, because it was not necessary to strip the settings so often to patch them. With that experience I felt I could specify two beds to be set in silica, but I was more or less in the hands of the retort setters with regard to the material used for the jointing. The silica selected—which was specified, I may say, so that the fault was not with the retort builder—was a well-known Scottish silica. I do not think it is necessary for me to mention the name. In the usual way, when setting such silica retorts, every care was taken to see that the joints were made as thinly as possible, and due allowance was made for the expansion which we know takes place with silica, more so than with the ordinary fireclay retorts. The jointing material used—and this statement will answer the questions of several speakers—was the cement supplied by the firm that made the silica sections (which I considered the correct kind of cement or jointing material to use) mixed with a small proportion of fireclay; and, inasmuch as the retort sections were only grooved, we found that during the working of the settings the jointing material gradually distributed and the retort became distorted. While we felt that we could possibly undertake the repair of such beds ourselves, in a manner similar to that which has been described so ably by Mr. Carr, of Stretford, the retorts were still under maintenance by the contractors, and were not altogether taken over. I might go a stage further and say that the heating of the settings was not altogether what we considered necessary, because a black patch appeared in the centre of the retorts, and we were unable to carbonize the full quantity of coal therein. The retorts were unevenly heated; and in order that the guarantee test figures could be obtained, certain working temperatures had to be attained which, in my opinion, were in excess of what they should be in ordinary everyday practice. We were working—in order to overcome the difficulty of the black patch in the centre of the retorts, and of incomplete carbonization thereby taking place—to a temperature of 1450° C., but after the contractors had left the works we dropped the temperature to 1350° C. To-day, in some of our new settings, where we have re-set, we are working even at from 1270° to 1300° C., and we anticipate that the life of the retorts will be much

longer. Inasmuch as these two silica retort beds were not actually taken over by the Company, and the heating was not really satisfactory, difficulties arose with regard to the pushing out of the charges from the retorts. In consequence we were not getting the throughput and the guaranteed make, and we had no alternative but to ask the contractors to replace them with other material. My Board felt that it was rather an unhappy start, and they did not feel justified in incurring any further expense with regard to re-setting in silica material. I was not able to convince them, after a failure of that description, that silica was proving efficient in many other works, and had proved efficient in the works I had been previously connected with; and, being cautious, they decided that the retorts should be set in fireclay. I hope that one of these days they will allow me to experiment again with another type of silica material, because, by working at a higher temperature, we should get a bigger throughput of coal and a larger output of gas for a given number of beds of retorts, and a lower carbonizing cost. It is disappointing to me, but I think you will agree with me in not putting in a greater number than we did. We feel we are getting excellent results to-day with the fireclay retorts, from Welsh coals, which are rather more difficult to deal with than are the English coals. Mr. Tarratt referred to the stubborn nature of the coal from the Durham coalfields. I think the Welsh coal is even worse, because not only do we have to deal with a coal which yields its gas very stubbornly, similar to that from the Somersetshire coalfields, but we have to contend with a very large ash content, sometimes up to 16, 17, and even 20 p.ct. That is one of the reasons why we are blending our coals to-day and mixing them with English coals. It is gratifying to know that, notwithstanding the fact that we have to work with a large percentage of Welsh coals, our figures are so satisfactory and compare very favourably with those of the very excellent installation at Stretford. While in some cases we have been able to show rather better figures than those obtained by Mr. Carr, in other cases our figures are not quite so good. This is due to the fact that we have to use local coal, which it sometimes pays us to use rather than to get other coals from a distant coalfield at greater cost. I am pleased to hear that at Liverpool water gas can be made more cheaply than coal gas. I was very near saying that, but I was rather afraid to do so, because it is generally understood to-day that water-gas making is not so economical as coal gas manufacture. The value of coke to-day is dropping, and we in South Wales have to face very keen competition with coke-oven coke, which is distributed freely in our towns at something like 15s. per ton. If we were to take a similar figure for our charges in connection with water-gas making, we, too, should find that water gas was coming out a little cheaper than coal gas. It is very gratifying to me to find that, notwithstanding the general opinion in the gas industry, it is a paying proposition, apart from the other advantages, to use a water gas plant to make water gas to-day in the way we do in conjunction with our coal gas plant.

I am afraid I did not make myself clear with regard to the number of mechanics in our works. It is obvious that we are not going to allow the plant to get into a dilapidated condition by starving it of attention. Our electrician lives on the works, and is available day and night, and, with the assistance of the Insurance Company, who act as a sort of sergeant or policeman, we are in a position to keep the plant in good running order. It is not our policy to reduce the number of workpeople, especially skilled workpeople, at the expense of the machinery. We have two leading men living on the works—the chief mechanic and the chief electrician. They are assisted by handy men, such as we train in gas-works, and who are capable of dealing with smaller repairs. The answer to the whole question is that we are able to run a works capable of an output of 5 million c.ft. per day with 72 men; and these figures are available in our wages books, and can be proved to any who doubt them. We have not made 5 million a day so far, but we have agreed with the Workers' Union as to the amount of work to be done by the respective men; and the figure I have mentioned is the number of men who will satisfactorily carry out that work. We have approached the 5 million output, but have never actually reached it.

As I have said, the discussion seems to have centred on the question of the silica retorts and the jointing material employed. Owing to the fact that the paper was not read in full, the members have not really had an opportunity to discuss it in the way it might have been discussed in ordinary circumstances. I should like to take this opportunity, however, of thanking the President for having given me the opportunity of contributing the paper.

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ABSTRACT OF NINETEENTH REPORT OF THE RESEARCH SUB-COMMITTEE OF THE GAS INVESTIGATION COMMITTEE OF THE INSTITUTION OF GAS ENGINEERS.

EXAMINATION OF PRODUCTS OF COMBUSTION FROM TYPICAL GAS APPLIANCES.

PART III.—APPLIANCES USING FREE-BURNING FLAMES.

For some years the Gas Investigation Committee has been interested in the nature of the products of combustion from gas appliances, and special attention has been given to the small amounts of carbon monoxide produced. Two reports on the subject have already been issued. The Fifteenth Report (1926) was devoted exclusively to the development and exhaustive testing of methods suitable for the determination of carbon monoxide. The Seventeenth Report (1927) dealt particularly with the CO production of gas fires.

The Nineteenth Report, now under review, while including additional information on gas fires, is mainly concerned with those appliances which work with free-burning flames—*i.e.*, the flames do not come into contact with solids, and there is not that obstruction which occurs, for example, with the mantle of the incandescent burner, with the radiant of the gas fire, and with a kettle placed over a ring burner.

There is a marked difference in the CO production of free-burning and partially obstructed flames, and it is therefore important that premature generalizations should not be made respecting gas appliances as a whole on the basis of results obtained with appliances using free-burning flames.

METHOD OF TESTING.

The method used for the determination of carbon monoxide is that described in the Fifteenth and Seventeenth Reports of the Committee, and depends on the liberation of iodine by the action of CO upon iodine pentoxide at 120° C. Carefully graded iodine pentoxide (30-50 mesh) was used, and special experiments with synthetic mixtures of CO and air at suitable concentrations showed that reaction with CO was quantitative under the conditions of the tests.

One important modification was made in the method—viz., the adoption of liquid-air condensation for the removal of oxides of nitrogen, as was proposed in the Fifteenth Report. These oxides are invariably present in the products of combustion, and interfere with the CO determination. They are of an acid character, and the reagent used for the absorption of CO_2 should therefore remove them; but though various alkalis were tried (potash solution, solid potash, soda-lime, soda-asbestos, and "Sofnolite"), none effected the complete removal of the oxides of nitrogen, and the routine apparatus now includes, after the CO_2 absorbent, a condensing tube immersed in liquid air (temperature, 190° C.).

Each test necessitates simultaneous determinations of CO and CO_2 both in the flue gases and in the air approaching the appliance.

FREE-BURNING FLAMES.

Before the tests with domestic appliances were undertaken, a series of experiments was conducted with certain types of flames burning freely in the open. These comprise luminous flames of the Argand and flat-flame types, and Bunsen burners with various degrees of primary aeration. The principal results are indicated in the following table.

It will be observed that in all cases the CO production is very small, and that there is little to choose in the various types of flame so far as CO production is concerned. This is a very important point, for the luminous flames are extensively used in geysers and thermostatically controlled water heaters owing to their freedom from liability to light back.

Free-Burning Flames.

Type of Burner and Flame.	Air-Gas Ratio.	Gas Rate. C.Ft. per Hour. (470 B.Th.U. Gas.)	CO Production. Parts per 10,000 of Gas Burned.*	CO Production. C.Ft. per Hour.
Argand burner with silica chimney		6·1	0·5	0·0003
		8·3	0·1	0·0001
Flat flame burner (No. 3 union jet)		2·7	1·1	0·0003
		6·4	0·6	0·0004
Flat flame burner (No. 3 geyser burner)		0·6	2·5	0·0002
		3·1	0·5	0·0002
		6·8	1·0	0·0007
Bunsen Burners.				
Mékerburner (30 mm.)	2·60	8·8	0·8	0·0007
Laboratory Bunsen ($\frac{7}{16}$ ina)—				
Hard. flame	2·48	5·3	0·9	0·0005
Soft ,,	1·24	5·3	1·3	0·0007
Luminous flame.	*nil*	5·2	2·1	0·0011

* In all the tests of this report, the concentration of CO in the theoretical dry products of combustion (*i.e.*, CO_2 + nitrogen, without any excess air) is approximately one-quarter of the figure quoted per 10,000 of gas burned.

In the Argand and flat-flame burners the structure of the flame is excellent for bringing together the gas and air for combustion, and this presumably accounts for the low CO production. The Argand flame yields the lowest CO production, and the flat-flame burners give a slightly increased production of CO per 10,000 of gas burned if the flames are turned low.

The Bunsen burners show a regular increase in CO production as the primary aeration is diminished, as noted also by other workers.

FLUELESS HEATER.

A small flueless heater of the condensing type was tested, using an Argand burner. When kept within its rated gas consumption (6 to 8 c.ft. per hour), the CO production was extremely low—viz., 0·1 part per 10,000 of gas burned. At 10 c.ft. per hour the appliance became greatly overheated, but the CO production rose only slightly.

The completeness of combustion in this appliance was remarkable, bearing in mind the small excess of air admitted to the burner—viz., 20 p.ct. of the theoretical air requirement of the gas used.

The condensate from the appliance was approximately 1½ pints per 24 hours, for continuous burning at 8 c.ft. per hour, corresponding with 20 p.ct. of the water produced by combustion of the gas; and the condensate retained approximately 25 p.ct. of the sulphur in the gas. (Sulphur content of gas = 23 to 24 grains per 100 c.ft.)

WATER HEATER.

A 3-gallon storage water heater was examined. It was intended for drawing-off hot water intermittently, and was fitted with a bi-metallic thermostat for automatically controlling the gas supply. It was fitted with four No. 2 geyser burners.

The gas consumption, after the thermostat had come into action, was 2·0 c.ft. per hour (470 B.Th.U. gas), and this was sufficient to maintain a temperature of 140° Fahr.

in the cistern. The CO production at this rate was 2·0 parts per 10,000 of gas burned. The maximum gas rate when cold water was flowing through the appliance was 18·3 c.ft. per hour, and the CO production then fell to less than 0·1 part per 10,000 of gas burned.

GEYSER.

A typical 2½-gallon geyser working on the "closed" water system was examined. It was installed in a very lofty bathroom (12 ft. high), so that it was possible to vary the height of the baffler above the geyser over quite a useful range.

The flue pipe connected to a geyser may be considered in two distinct portions—that above the baffler and that between the baffler and the geyser. Flue pipe above the baffler is undoubtedly of service in securing the removal of the products of combustion from the room, but it will have a negligible effect upon the draught through the geyser if the baffler is properly designed. The portion below the baffler may be expected to have a direct influence upon the draught through the combustion chamber, and it is this length (measured from the top of the geyser to the break in the baffler) which was varied in the experiments, and is used in plotting the diagram below. The products of combustion were sampled from the top of the geyser, and were drawn directly into the carbon monoxide apparatus in the adjoining room.

The results of the tests are shown graphically for a mean gas rate of 136 c.ft. per hour, which was the gas rate attainable with this geyser at a pressure of 2½ in. w.g.

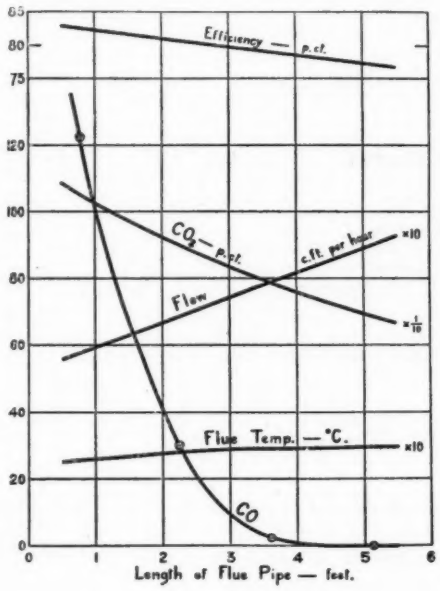


Fig. 6.—Results of Geyser Tests.

Values read from diagram must be multiplied by factor attached to each curve.

CO is given in parts per 10,000 of gas burned.

Length of flue pipe is measured from top of geyser to break in baffler.

The curve showing the relation between flue length and CO production per 10,000 of gas burned is very striking, and is in agreement with the observed behaviour of the appliance.

Tests with a very short length of flue pipe were made by attaching the baffler directly to the geyser, the "length of flue pipe" being the 9½-in. piece forming the lower part of the baffler; flue pipe was added above the baffler to reach into the false roof. There was slight escape of products of combustion at the lighting opening and below the geyser stand, and the products had the objectionable odour usually associated with imperfect combustion. The flames, especially those of the outer ring, were "floating" and intermittently extinguished. The CO production was more than 1·2 p.ct. of the gas burned, and the concentration of CO in the flue gases themselves was 30 parts per 10,000.

The draught up the centre of the geyser was distinctly stronger than up the sides, and though the flue gases on the average show an excess of air (equal to approximately 20 p.ct. of the theoretical air requirement), there may be a local deficiency of air, especially near the outer ring of burners, which would account for the high CO production. Experiments showed that, even with this undesirably short flue pipe, combustion could be made satisfactory by reducing the gas rate by 20 p.ct.

With the baffler raised 5 ft. above the top of the geyser, a greater height than will generally be practicable, the flames were satisfactory and the CO production extremely low. There was no opportunity of judging the available margin with this length of flue pipe, as the gas pressure was not sufficient to give any considerable increase in gas rate.

Tests were made with the baffler at intermediate positions. In order that the concentration of CO in the flue gases should not exceed 2 parts per 10,000 of gas burned, it would be necessary in the case of this geyser to have at least 3 ft. of flue pipe below the break in the baffler. From the curves given, this means that the concentration of CO_2 in the flue gases should not exceed 8·3 p.ct.

A higher pressure, and consequently a higher gas rate, would be attainable at the more elevated points on the district. Unless a flue length greater than 3 ft. were available, however, it would be necessary to limit the gas consumption for this geyser to the figure we have just given—viz., 136 c.ft. per hour.

The thermal efficiency of the geyser was high, 78 to 83 p.ct. on the gross calorific value of the gas, the variation being accounted for by the difference in the flue losses, which increased slightly as the draught through the geyser was increased by lengthening the flue pipe.

JUNKERS CALORIMETER.

In this calorimeter a single Bunsen flame burns in a water-cooled combustion chamber, but without contact with any of the cold metal surfaces. It was tested at about 6½ c.ft. per hour with the air-slide adjusted to give a well-aerated flame and with the flue-outlet restricted to a circular hole ⅝ in. diameter—a condition which has been found satisfactory for calorific value determinations.

The carbon monoxide production (0·2 part per 10,000 of gas burned) was lower than for the free-burning Bunsen flames already mentioned. A similar reduction was observed in the case of the water heater and the gas oven, and is probably the result of using a smaller draught past the flame, so that, while the air supply is still ample, there is less cooling of the flame than would otherwise occur.

As supplementary evidence of the satisfactory combustion in this calorimeter at the gas rate used, it may be noted that with the same restricted damper opening, it is possible to double the above gas rate and obtain only a small drop in the apparent calorific value of the gas; and this is covered by corrections for slightly increased radiation and flue losses. If, however, the gas rate is increased beyond 14 c.ft. per hour, the apparent C.V. falls rapidly, due to incomplete combustion, and there is an objectionable odour from the exit gases. Carbon monoxide determinations corresponding to these conditions were not made.

GAS OVEN.

A typical medium-sized gas oven was tested with two side burners and top flue outlet (area 6 sq. in.). A group of tests at successively increasing gas rates was first made with the *empty oven*, rising to a gas rate and oven temperature much in excess of any domestic requirement. Except that for test purposes the oven was allowed several hours in each case to attain thermal equilibrium, the conditions for the higher gas rates would correspond with those obtaining when the oven is rapidly heated in preparation for cooking. In order to attain these high gas rates with the available pressure, the gas nipples were used almost at their maximum opening, and the air shutters were also fully open.

With the 470 B.Th.U. gas in use, the flame characteristics were excellent from 15 c.ft. per hour up to the highest rate examined; but at 10 c.ft. per hour the flames had luminous tips and there was slight escape of gas from the air intake. This condition was rectified by a small readjustment of the nipple for the low rate test. In none

of the above tests was there any sign of "floating" or smothering of the flames.

The principal results of the test are indicated by fig. 7.

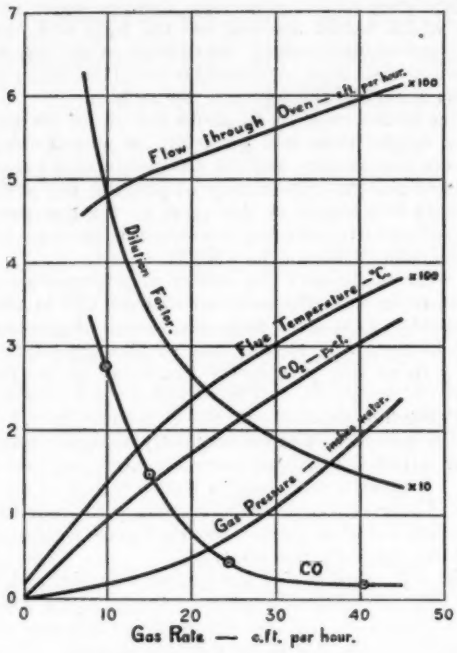


Fig. 7.—Results of Oven Tests.

Values read from diagram must be multiplied by factor attached to each curve.

CO is given in parts per 10,000 of gas burned.

The figures show a reduction in the CO production per 10,000 of gas burned as the gas rate is increased, with a relatively large drop in the early stages. At the low gas rate, the flames, which issue from the *side* of the burner, are small and seem to cling to the ironwork; this will produce a certain amount of cooling of the flames (even their extinction in the layer in contact with the burner) and would account for the slightly higher CO production.

Even at the highest gas rate there is no shortage of air, and no evidence of imperfect combustion, which at this rate might have been anticipated.

In the Special Report of the Gas Investigation Committee dealing with the Standard Method of Testing Gas Ovens, considerable stress was laid upon the importance of luting all joints and placing a load in the oven, in order to increase the stringency of the "smothering" test. Tests made after luting all joints except the door showed that the influence upon CO production was negligible; there was a slight reduction in the flue losses.

Tests were next made at the normal gas rate and at a high gas rate after luting all joints, including the door joints, and loading the oven with six bread tins filled with dry sand. Conditions within the oven were appreciably altered by this treatment and there was distinct softening and lengthening of the flames on closing the door, though at 40 c.ft. per hour they would still be regarded as well-aerated and burning in a satisfactory manner. The CO production was not essentially different from that obtained in the tests with the empty oven, though the temperature distribution and flow of air and products through the oven were considerably modified.

At 50 c.ft. per hour the flames of the right-hand burner began to "float," but the conditions could not be maintained for a sufficient length of time for a reliable CO determination.

A test of the oven with the burners in a "struck-back" condition was made by lighting the gas at the nipple, yellow flames being produced at the burner outlets. This state of affairs is usually regarded as dangerous, but there was no objectionable odour from the flue outlet, and the CO production, although slightly higher than for normal combustion, was surprisingly small.

When the gas was burning at the nipple, but *not* lighted at the burner head, there was an objectionable smell. The CO production in this case was not determined, but from experience with other appliances (e.g., the geyser with deficient air supply) a high figure might be expected.

Gas Fire.

A limited number of tests were conducted with Gas Fire "A" of the Seventeenth Report (modern 9-radiant fire) to ascertain the correction which should be applied in consequence of the modified method of testing.

Generally speaking, the use of a liquid-air condenser in the testing trains would reduce the apparent CO figure for those tests by 9·0 parts per 10,000 of gas burned.

Some of the newer figures for CO production are, however, higher than those of the Seventeenth Report, due to differences in gas quality and adjustment of the fire. While, therefore, the individual tests of the Seventeenth Report require correction to the extent indicated, the uncorrected results given in the Summary of that report fall within the range of typical CO production figures for gas fires working under normal conditions.

It may be said that a modern gas fire, properly adjusted, working up to its full rated capacity of 2000 B.Th.U. per radiant per hour, should not produce a greater volume of CO than 0·5 p.ct. of the gas burned (*i.e.*, 50 parts per 10,000 of gas burned). The essential conclusions of the Seventeenth Report respecting the relation between CO production and gas rate are not affected by the method of testing now adopted.

The following table indicates the conditions under which the various appliances were tested, and summarizes the principal results obtained.

Summary Showing CO Production by Appliances Tested.

Appliance and Conditions of Test.	CO_2 in Flue Gases P.Ct.	Gas Rate, C.Ft. per Hour.	CO Production. Parts per 10,000 of Gas Burned.	CO Production. C.Ft. per Hour.
FLUELESS HEATER (condensing stove) with Argand burner		6	0·1	0·0001
		8	0·1	0·0001
Ditto, overloaded		10	0·5	0·0005
WATER HEATER with 4 No. 2 geyser burners and thermostatic control—				
When maintaining 140° Fahr. in cistern		2·0	2·0	0·0004
At maximum gas rate		18·3	0·1	0·0001
GEYSER (2½ gallon size) with 36 No. 1 geyser burners—				
Length of flue pipe below baffler: 5 feet	7·0	136 approx.	0·1	0·001
4 ,,	7·6		1	0·01
3 ,,	8·3		9	0·12
2 ,,	9·2		41	0·56
1 ,,	10·2		101	1·37
¾ ,,	8·5	108	1·5	0·016
CALORIMETER (Junkers with Bunsen burner)		6·7	0·2	0·0001
GAS OVEN (2 side burners and top flue outlet)—				
Empty oven		10	2·7	0·0027
		15	1·5	0·0022
		20	0·8	0·0016
		30	0·3	0·0009
		40	0·2	0·0008
Oven loaded, all joints luted, including door joints		25·3	0·0	0·0000
		39·0	0·3	0·0012
GAS FIRE (9 radiants)—	Air-Gas Ratio.	*		
Very soft flames	1·13	79	74·9	0·225
Soft flames	1·42	102	73·3	0·287
Shorter flames (increased amount of water gas)	1·42	100	27·2	0·104
Test with radiants removed	..	82	6·2	0·019

* Gas rate expressed as p.ct. of normal gas rate (2000 B.Th.U.) per radiant per hour.

Discussion.

Dr. E. W. Smith: There is a question I should like to ask. Prof. Cobb said it has been found that where gas flames impinge on (say) a refractory material such as the radiant of a gas fire, the carbon monoxide is likely to be higher than in cases where a similar flame, I assume, is burning in the open without any interference. I should like to ask whether Mr. Wood has checked whether that is due, not to interference, but to the fact that in a gas fire arrangements are made deliberately for the flame to fit the radiant, and that at the back of the radiant there are what appear to be louvres, in order to admit the secondary air, it being known from the beginning that the

amount of air mixed with the gas prior to ignition is perhaps half that required for complete combustion, and that the rest of the air has to go through the sides of the radiant for complete combustion. It is conceivable to me that the amount of air that is admitted is insufficient, and that the flame fits the radiant too closely, so that when the products of combustion reach the top of the radiant there is unburnt gas, and that the carbon monoxide is surrounded by such a large volume of products of combustion that, prior to the carbon monoxide being able to combust with further air, the temperature of the product has dropped, and it is not possible to get complete combustion in that small trace. I submit it is highly probable that under right conditons quicker and more complete combustion should take place in contact with a refractory material at a temperature well above 850° C. I think this report is very excellent and valuable, and requires all the encouragement the Institution can give to it.

Mr. T. F. E. RHEAD (Birmingham): I notice Mr. Wood mentions that in the Junkers calorimeter, owing to the reduced amount of air passing up with the flame, there is a slightly reduced amount of carbon monoxide. Many of these free-burning appliances are placed in draughty positions, and I was wondering whether he has any indication of the increased amount of carbon monoxide produced under such conditions.

Dr. W. B. DAVIDSON (Newcastle-on-Tyne): During the reading of the report I was impressed with regard to the question of the formation of oxides of nitrogen, and was wondering if we could now take credit, as gas manufacturers and consumers, for fertilizing the country. As you know, oxides of nitrogen are synthetic nitrogen products, which are artificial fertilizers; but perhaps we can hardly claim advantages in that respect, as they will be set off against the disadvantage which we know we are labouring under in producing small quantities of sulphuric acid. It is a very small quantity, less than 1 p.ct. of what is made with coal. I also notice that in fully aerated flames such as the Méker flame, the amount of carbon monoxide is the minimum; it is distinctly smaller than in the case of less well aerated flames. I think this is a matter which requires serious study. I think the best flames, the flames that we ought to try to produce, are those of the solid uniform type, well aerated, or the Méker flame, and I must say that these are more readily produced with low-grade gas at good pressure than with high-grade gas at ordinary pressure. Another point I should like to raise is this. When you say that the quantities of carbon monoxide produced are small, and you wish to improve matters, you must not be misled by decimal points. For instance, if you produce 0·8 part per 10,000 c.ft., as against 1 part, that is a reduction of 21 p.ct. If you think only in decimals, it appears to be a mere nothing.

Mr. WOOD, replying to the discussion, said: I believe Dr. Smith's questions are answered partly, if not completely, by the information given in the Seventeenth Report, respecting gas fires. I believe Dr. Smith is a believer in the theory that a really hot refractory substance ought to accelerate and complete combustion in the presence of an adequate supply of air. In the gas fire the products of combustion are leaving a relatively cool, and not a hot, refractory. As you increase the gas rate on a standard type of gas fire you find that the carbon monoxide in the products of combustion gradually increases up to a certain point. The mixture leaving the top of the radiant is too feeble to burn; but if you make matters a little worse you finally reach a mixture which is strong enough to burn and continues to burn above the radiant, and you find by experiment that, when you have reached the stage at which definite flames are present above the top of the radiant—and one that is usually regarded as very bad practice—the amount of carbon monoxide in the products of combustion themselves is actually smaller than when the flames are right inside the radiant. I do not think it is good practice, all the same, if you are attempting to heat the radiant, to burn a lot of gas above the radiant.

Mr. Rhead raised a question which is important in connection not only with carbon monoxide, but with calorimetry. We have worked the bunsen burner of the Junkers calorimeter, which burns in a combustion chamber about 3 in. in diameter, with the minimum safe draught, giving 6 or 7 p.ct. of carbon dioxide in the flue gases. We have not, with that appliance, determined the carbon dioxide figure and the minimum air supply before the carbon monoxide becomes bad, nor the effect of draught upon carbon monoxide production; but the appliance is one which is eminently suitable for that type of experiment.

Mr. RHEAD: My question really related to the ordinary appliance which is used in the ordinary living room. Would a draught upon it cause an increased production of carbon monoxide? I was using your simile of the Junkers calorimeter to illustrate the point.

Mr. WOOD: Well, there is a very considerable difference between the steady streamline draught through the calorimeter, which follows the outline of the flame and is quite steady, and the intermittent, and particularly the side, draught of the puffs of wind which interfere with the flame burning freely in the open. We have had cases, particularly the one of the flame with no primary air, in which the carbon monoxide found free in the air has been considerable.

I am not quite sure whether or not I misunderstood Dr. Davidson. The oxides of nitrogen which are produced during the burning of gas are derived partly from the nitrogen of the air which enters into the combustion, and not exclusively from the nitrogen present in the gas. The amounts are extremely small. Commercial processes for the recovery of the oxides of nitrogen are worked with appliances, when worked under most favourable conditions, at high temperature and pressure, with only about a quarter of the nitrogen. As far as the gas engineer is concerned the production of oxide of nitrogen is a distinct disadvantage, and in the presence of sulphur compounds may be the cause of some of our corrosion troubles in connection with gas fittings.

The quantities of carbon monoxide are so small that the practical result of altering the quantities by 20 p.ct. would be of no consequence.

ABSTRACT OF THE TWENTIETH REPORT OF THE RESEARCH SUB-COMMITTEE OF THE GAS INVESTIGATION COMMITTEE OF THE INSTITUTION OF GAS ENGINEERS.

STUDIES IN CARBONIZATION.—PART III.

TEMPERATURE, SIZE OF COAL, BLENDING WITH COKE AND INORGANIC COMPOUNDS.

The object of the investigation, of which the third stage is described in this report, is a study of the various factors which may influence the yields and physical and chemical properties of the products obtained when coal is carbonized. The whole of the experiments described in this report and in the Sixteenth and Eighteenth Reports were conducted with a Nottinghamshire gas coal of moderate coking properties. When carbonized in full-scale horizontal retorts, this coal yields approximately 12·2 cwt. of coke per ton, 12·7 gallons of tar, and gas with a gross heat content of 70 therms.

Apart from experiments in which different types of coal are to be blended with one another, the carbonization experiments planned for the Nottinghamshire coal have been completed, though some of the cokes produced required further examination as regards physical structure, ignition temperature, and reactivities towards steam and carbon dioxide.

The experiments were arranged with the object of obtaining information on the influence of

(*a*) grading the coal in different sizes,
(*b*) the admixture of different sizes of coal,
(*c*) the temperature of the retort,
(*d*) the addition of coke breeze to the coal, and
(*e*) the addition to the coal of calcium carbonate, iron oxide, and sodium carbonate.

The experimental plant specially designed for the investigation was fully described in the Sixteenth Report. For the third series of experiments, however, some improvements, mainly in the scrubbing and purifying system, have been made. It seems desirable, therefore, that a

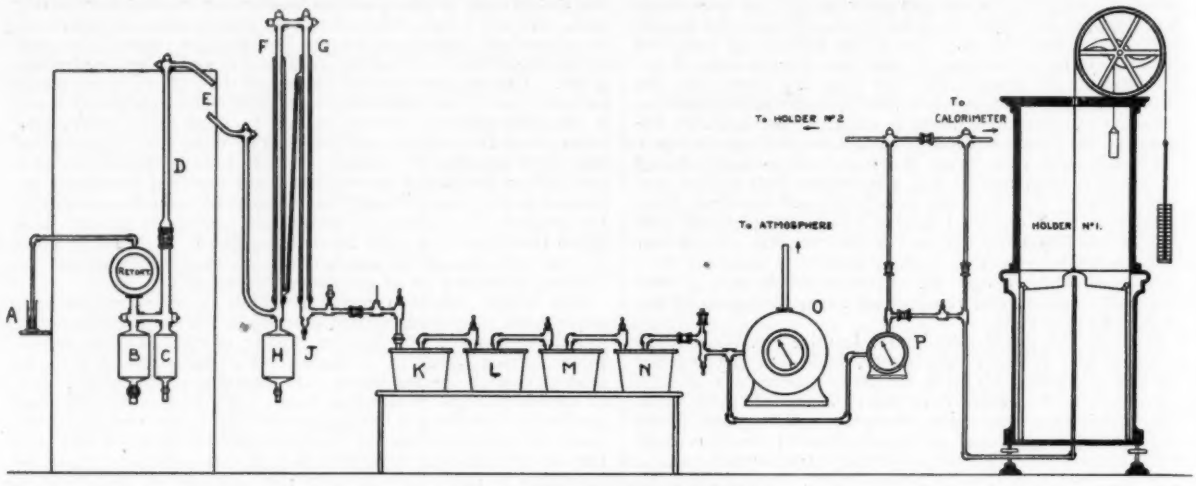


FIG. 1.—EXPERIMENTAL PLANT.

brief description of the plant as now arranged should be given.

Experimental Plant.

The experimental plant, fig. 1, includes a horizontal retort closed at one end, condensers, ammonia scrubbers, purifiers, gas meters, and gas sample holders. The retort, which was cast from an alloy, "cronite," and was installed three years ago, is still perfectly gas-tight, and does not show any signs of deterioration. The carbonization temperatures recorded in all experiments were taken by means of a thermo-couple placed in an annular space surrounding the metal retort. The temperatures of the combustion chambers were, of course, much higher.

The mouthpiece of the retort is provided with a gas offtake situated as shown in fig. 1. Since the condensers, scrubbers, and purifiers with open seals, as described in the Sixteenth Report, have been replaced by closed vessels, a safety pipe has been fitted to the top of the mouthpiece. The open end of the safety pipe is sealed in a vessel A containing mercury, from which gases and vapours would escape if a stoppage should occur in any portion of the plant following the retort. The collecting pots B and C for tar and liquor are employed only when the carbonization is conducted with the retort at temperatures below 750° C. Above this temperature, these two pots are replaced by metal plugs.

From the retort, the gases and vapours travel through the ascension pipe, D, and then through the water cooled condensers E, F, and G. Tar and liquor which deposit in the condensers E and F flow into the collecting pot H; and any condensate from G is withdrawn through the cock J. The gas leaves the condensers at atmospheric temperature and travels through the scrubbers K and L and the purifiers M and N, before passing through the measuring and sampling meters O and P.

Each scrubber and purifier is made of cast iron, and consists of a rectangular box, fig. 2, designed to operate on

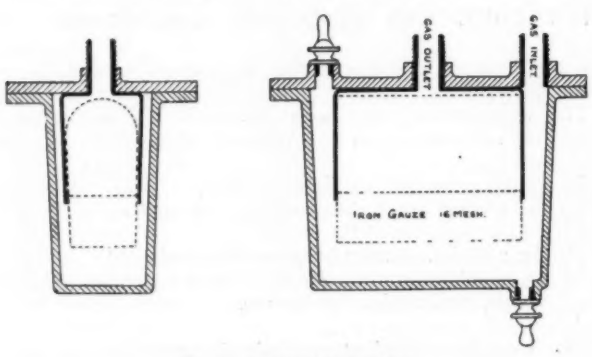


Fig. 2.—Diagram of Scrubber.

the principle of the Livesey washer. In the experiments so far conducted with the plant arranged as shown in fig. 1, each scrubber was supplied with a measured quantity of water, and each purifier was provided with an aqueous solution of caustic soda of determined concentration, approximately 12 p.ct. The washing liquids were removed for measurement and analysis at the end of each experiment. Water has proved to be a satisfactory solvent for ammonia; but if necessary in experiments under other conditions, a scrubber containing a dilute solution of sulphuric acid, and constructed of suitable material, will be installed. The purifiers remove sulphuretted hydrogen with greater efficiency than those previously employed, so that it has been possible to dispense with the auxiliary purifier formerly required for final purification of the gas which passed through the meter P to the sample holder. The new system of scrubbing and purifying the gas is a distinct improvement on that described in the Sixteenth Report, in that no open seals are employed and frequent attention to supply jets and storage vessels for washing solutions is avoided; in addition, tar fog is more efficiently removed from the gas.

The method described in the Sixteenth Report of obtaining representative samples of the gas made, by an arrangement of two gas meters with inlet gas supplies in parallel and the centre spindles connected by shafting and gearing, continues to operate satisfactorily; and the chart recorder designed for the purpose of automatically registering rates of gas production has proved its reliability. A continuous record of the temperature of the gas made as it passes through the meters is now obtained by a Callendar recorder. These temperature records, combined with barograph charts, provide the data for correcting the measured gas volumes to standard conditions.

Experimental Results.

It is not possible in a summary of this kind to do more than indicate the general nature of the results obtained and to illustrate the conclusions by a few typical examples. Fifty-two tests under different conditions, with the retort at eight different temperatures proceeding downwards from those equivalent to normal high-temperature practice to 344° C., have been completed with the Nottinghamshire coal. Thirty-two tests are described in the text of the Twentieth Report, which includes sixteen figures and twenty-five tables, setting forth carbonization results, the compositions of the products, and carbon, weight, and thermal balances; in addition, the results are correlated with the previous twenty tests described in the Sixteenth and Eighteenth Reports.

Size of Coal.

Several grades of sizes of the coal, ranging from the size 1¼ in. to ⅜ in. down to 8 to 30 mesh, were carbonized separately and in admixture with one another with the retort at five different temperatures from 980° C. to 630° C. In two experiments, mixtures of sizes containing 25 p.ct. of the grade through 30 mesh, were employed. In addition, the size 8 to 30 mesh was carbonized at 525° C., 435° C., and 344° C. At each temperature, the

carbonization was allowed to continue until the rate of gas production had become comparatively small.

With the retort at any given temperature below 820° C., the total yields of coke, tar, liquor, and gas were not greatly affected by alterations in the size-grading of the coal. When carbonization was carried out at the higher temperatures, 980° C. and 915° C., the total volumes and thermal values of the gas made were lower with the largest grade of coal, 1¼ in. to ¾ in., and the yields of tar were greater than with the smaller grades. For example, the amount of gas obtained at 980° C. with 1¼ in. to ¾ in. coal was 12,170 c.ft., or 72·3 therms, per ton, whereas the average yield of gas from the smaller sizes of coal was 12,645 c.ft., or 74·3 therms.

Though the total volumes of gas made at given temperatures, when carbonization had been completed, were generally independent of the size grading of the coal, the rates at which gas was evolved as the carbonization proceeded varied considerably. In the earlier stages of carbonization, gas was evolved most rapidly from the largest grade of coal, and the rate of gas production decreased with diminution in the size of coal. With mixtures of sizes, the rates of gas production were slightly lower than with the smallest grade, 8 to 30 mesh, carbonized alone. Some typical results are given in Table I. of this summary. The general influence of sizes of particles of coal on the total volumes of gas produced at different stages of carbonization is illustrated by the curves in fig. 3, in which

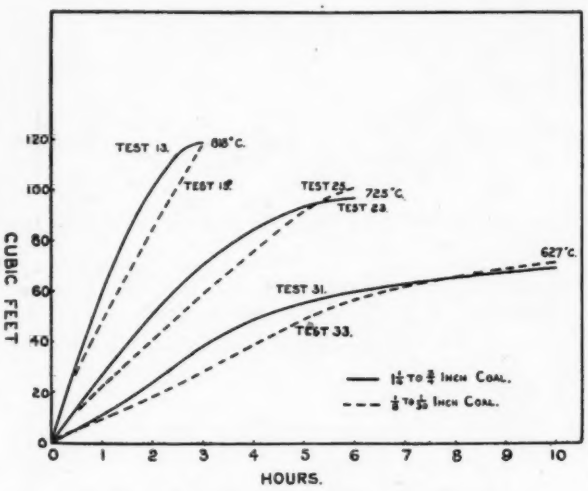


Fig. 3.—Gas Production—Influence of Size of Coal.

volumes in c.ft. are plotted against times of carbonization for the grades 1¼ in. to ¾ in. and 8 to 30 mesh at three different temperatures.

Measurements of rates of gas production are of value when considering at what stage processes of carbonization cease to be economical. The important influence of size of coal may be illustrated by the fact that in those experiments in which the temperature of the retort was 815° C. and the complete period of carbonization was three hours, the volume of gas made at the end of one hour was 28 p.ct. more with 1¼ in. to ¾ in. coal than with a mixture of four sizes, 21 p.ct. more at the end of two hours, and 12 p.ct. more after 2½ hours. With the retort at 915° C., the volume of gas made after one hour was 17 p.ct. greater with ½ in. to ¼ in. coal than with a mixture of four grades, and the difference was 8 p.ct. after two hours. Expressed in another form, 90 p.ct. by volume of the total gas made at 915° C. from ½ in. to ¼ in. coal had been obtained in 102 minutes, whereas the production of the same amount of gas occupied 121 minutes, or 19 p.ct. more time, with a mixture of four grades of sizes of coal.

Considerable economies might, therefore, result from the screening of coal for gas production, the screened coal and the fines being carbonized separately.

Temperature of Retort.

The time required for satisfactory carbonization with the retort at any particular temperature was determined from a preliminary experiment in which readings of the gas meters were taken at definite intervals of time, the carbonization being continued until the rate of gas production had become comparatively small. As the temperature of the retort was lowered, the period of carbonization increased rapidly from 2½ hours at 915° C. to 10 hours at 630° C., and 20 hours at 525° C. The influence of temperature on the time required for carbonization is illustrated graphically in fig. 4, in which time in hours is

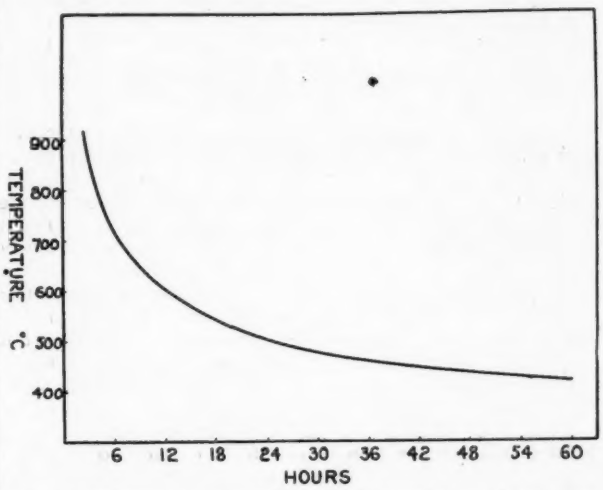


Fig. 4.—Influence of Temperature on Time Required for Carbonization.

plotted against temperature. The time factor is of importance when considering low-temperature carbonization

TABLE I.—*Gas Made in C.Ft. per Charge of 30 Lbs. of Coal. Influence of Size of Coal.*

Temperature of Retort, °C.	980.		915.			815.			725.	
Test No.	B.	E.	2.	3.	7.	13.	15.	17.	23.	26.
Size of Coal, In.	¾ to ⅜.	⅛ to 30.	½ to ¼.	⅛ to 30.	Mixture.*	1¼ to ¾.	½ to 30.	Mixture.†	1¼ to ¾.	Mixture.‡
Time of Carbonization. Hrs. Mins.										
0 15	48·1	41·3	37·1	33·5	30·1	16·2	16·2	14·7	6·7	6·8
0 30	77·5	66·9	60·9	55·2	50·7	31·3	27·3	25·4	13·2	12·0
0 45	101·3	88·7	81·2	74·4	68·8	45·1	37·4	35·5	19·6	16·6
1 0	120·9	108·0	99·3	91·9	85·1	57·9	47·0	45·2	26·1	21·2
1 15	138·2	125·5	115·2	108·2	100·4	70·2	56·4	54·8	..	..
1 30	151·6	141·2	129·5	122·9	114·5	81·4	65·6	64·3	38·8	30·0
1 45	158·7	153·7	142·2	136·4	127·6	91·4	74·5	73·8	..	..
2 0	161·5	160·9	150·7	147·3	139·5	100·6	83·6	83·2	50·6	38·9
2 15	163·1	163·6	154·0	152·3	149·9	108·6	92·6	92·5	..	..
2 30	164·3	165·3	155·9	154·6	158·1	114·1	101·5	101·8	61·0	47·9
2 45	165·1	166·4	..	..	..	117·2	110·0	110·9	..	..
3 0	..	..	..	..	..	119·0	118·4	119·5	69·9	57·0
4 0	..	..	..	..	..	..	..	..	84·3	74·0
5 0	..	..	..	..	..	..	..	..	93·2	87·3
6 0	..	..	..	..	..	..	..	..	97·1	97·1

* Mixture of equal weights of four sizes—1¼ in. to ¾ in., ¼ in. to ⅛ in., 10 to 30 mesh, and through 30 mesh.
† " " " " " " 1¼ in. to ¾ in., ¼ in. to ⅛ in., 8 to 30 mesh, and through 30 mesh.
‡ " " " three " 1¼ in. to ¾ in., ¼ in. to ⅛ in., 8 to 30 mesh.

TABLE II.—*Results per Ton of Coal, 8 to 30 Mesh.*

Test No.	E	3	15	25	33	39	43	44
Temp. of retort, ° C.	979	918	819	726	630	527	435	344
Gas made, c.ft.	12,640	11,880	9206	7757	5548	3234	1912	509
Composition of gas, vols. p.ct.—								
CO_2	2·9	3·5	4·5	4·0	4·5	9·4	10·5	22·8
C_mH_n	5·0	4·4	5·3	5·2	3·9	3·6	3·1	2·6
O_2	0·3	0·3	0·2	0·2	0·2	0·4	0·6	1·2
CO	11·4	11·7	10·6	10·1	8·6	6·6	4·7	3·2
H_2	51·1	51·2	45·1	38·0	32·2	17·5	12·3	6·0
C_nH_{2n+2}	26·1	27·5	32·5	40·9	49·2	60·2	63·5	52·8
N_2	3·2	1·4	1·8	1·6	1·4	2·3	5·3	11·4
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
Value of "m" in C_mH_n	..	..	2·7	3·0	3·5	3·6	4·1	4·1
Value of "n" in C_nH_{2n+2}	1·04	1·05	1·09	1·13	1·17	1·26	1·38	1·82
C.V. of gas, B.Th.U. per c.ft., gross	600	593	643	737	807	900	1004	943
C.V. of gas, therms per ton of coal	75·8	70·4	59·2	57·2	44·8	29·1	19·2	4·8
Specific gravity of gas (air = 1)	0·45	0·45	0·49	0·51	0·56	0·70	0·78	1·00
Coke (dry) in cwt.	12·9	13·0	13·3	13·4	13·65	14·75	15·7	17·25
Tar and pitch, lbs.	111	116	145	167	182	168	140	71
Specific gravity of tar	1·19	1·18	1·13	1·10	1·07	1·03	1·01	0·98
Liquor, gallons	24·0	23·4	25·5	27·2	26·4	25·7	24·3	20·3
Ammonia expressed as ammonia sulphate, lbs.	22·0	25·1	32·5	33·6	22·8	6·2	5·1	2·1
H_2S, grains per 100 c.ft. of gas	430	400	420	520	780	1290	1690	380

with static charges and external heating only, and the appreciation of this factor has already resulted in a number of inventions and suggestions in connection with low-temperature processes.

The volume of gas produced with 8 to 30 mesh coal decreased from 12,640 c.ft. per ton with the retort at 979° C., to 5548 c.ft. at 630° C., and 1912 c.ft. at 435° C. The gross calorific values of the gas made at these three temperatures were 600, 807, and 1004 B.Th.U. per c.ft. respectively, so that the total heat values of the gas per ton of coal fell from 75·8 therms at 979° C. to 44·8 therms at 630° C. and 19·2 therms at 435° C.

The average compositions of the gas derived from the 8 to 30 mesh coal at different temperatures are given in Table II., which also includes other data. The proportion of carbon dioxide in the gas ranged between 2·9 p.ct. and 4·5 p.ct. when the retort was heated above 600° C., but a reduction in temperature below 600° C. caused a large increase in the percentage of this constituent to 22·8 at 344° C. As the temperature of carbonization was reduced, the proportion of carbon monoxide fell gradually to 10·1 p.ct. at 726° C., and then more rapidly to 3·2 p.ct. at 344° C., the hydrogen content decreased from 51 p.ct. to 6 p.ct., and at the same time the methane hydrocarbons increased from 26·1 p.ct. to 63·5 p.ct. at 435° C. and then decreased to 52·8 p.ct. at 344° C. The value of "*m*" in the hydrocarbons of the general formula C_mH_n rose from 2·7 at 819° C. to 4·1 at 344° C., and the value of "*n*" in the methane hydrocarbons rose from 1·04 at 979° C. to 1·82 at 344° C. The changes in the compositions of the gas made as regards carbon dioxide, carbon monoxide, hydrogen, and methane hydrocarbons with alterations in the temperature of carbonization are shown graphically in fig. 5.

The temperature of the retort exerted a great influence on the rate of gas production. At the end of one hour, the volumes of gas produced at 630° C. and 819° C. (Table III.) were only 9 p.ct. and 44 p.ct. respectively of the

TABLE III.—*Gas Made in C.Ft. per 30 Lbs. of Coal as Charged.*

Size of Coal, 8 to 30 Mesh.

Test	E	3	15	25	33	39	43	44
Temp. of retort, ° C.	979	918	819	726	630	527	435	344
Time of carbonization—								
1 hour	108·0	91·9	47·0	21·9	9·4	3·1	1·4	0·6
2 hours	160·9	147·3	83·6	40·1	18·3	5·2	1·6	0·7

volume made in the same time at 979° C. Adopting another method of comparison (Table IV.), the evolution of 50 c.ft. of gas from 30 lbs. of coal required 0·33 hours at 979° C., 1·08 hours (or three times as long) at 819° C., and 5·17 hours (or sixteen times as long) at 630° C.

The weights of dry coke or semi-coke made increased as the temperature was lowered, from 12·9 cwt. per ton of coal at 979° C. to 17·25 cwt. at 344° C. The amount of volatile matter in the coke increased from 2 p.ct. with the retort at 979° C. to 6 p.ct. at 630° C., and 26 p.ct. at 344° C.; and the corresponding amounts of hydrogen in the coke were 0·5 p.ct., 2·1 p.ct., and 4·4 p.ct. respectively.

TABLE IV.—*Time in Hours for Production of 50 C.Ft. and 100 C.Ft. Gas from 30 Lbs. 8 to 30 Mesh Coal.*

Test	E	3	15	25	33
Temperature of Retort, °C.	979	918	819	726	630
Volume in c.ft. 50	0·33	0·43	1·08	2·53	5 17
" " 100	0·88	1·12	2·45	6·00	..

The total weight of tar and pitch rose from 111 lbs. per ton of coal with the retort at 979° C. to a maximum of 182 lbs. at 630 C. and then fell to 71 lbs. at 344 C.; at the same time, the specific gravity of the tar steadily decreased from 1·19 to 0·98. The maximum yields of liquor and ammonia were obtained at 726° C. and the minimum at 344° C. The amount of sulphuretted hydrogen in the crude gas was approximately 400 grains per 100 c.ft.

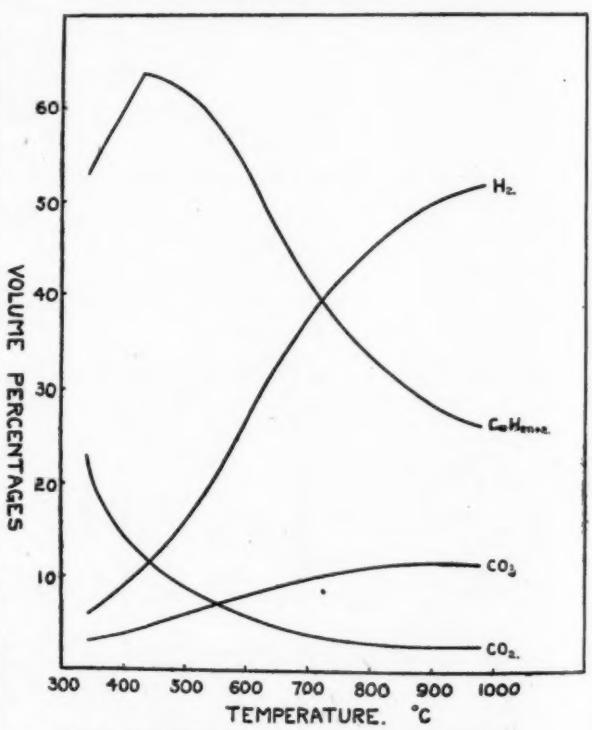


Fig. 5.—Composition of Gas—Influence of Temperature.

with retort temperatures above 800° C., but below this temperature the quantity increased, as the temperature was lowered, to 1690 grains at 435° C., and decreased to 380 grains at 344° C.

MIXTURES OF COAL AND COKE.

To ascertain whether the addition of coke breeze to the 8 to 30 mesh coal influenced the carbonization process, mixtures containing 10 p.ct. and 20 p.ct. by weight of coke were carbonized with the retort at 915° C. and 815° C., and the 10 p.ct. mixture was also carbonized at 725° C. and 630° C. The addition of coke breeze had no marked effect on the compositions and calorific values of the gas made; and the yields of gas and tar expressed in amounts per ton of coal were not greatly altered. Larger quantities of ammonia were obtained in all tests with coal-coke mixtures than with coal alone.

The volumes of gas evolved from each retort charge at corresponding periods of carbonization were less with the coal-coke mixtures than with the coal alone. In this connection, it should be pointed out that each charge of coal contained 30 lbs., but the weights of coal per charge with the mixtures were necessarily less—27 lbs. in the mixture containing 10 p.ct. coke, and 22 lbs. with 20 p.ct. coke.

From the results obtained, it may be concluded that the disadvantages more than counterbalance the advantages of blending coke with the *particular coal of moderate coking properties* examined. In this connection it should be noted that the mixtures were not briquetted before carbonization. The influence of briquetting is to be examined later.

MIXTURES OF COAL WITH INORGANIC COMPOUNDS.

Separate mixtures of the 8 to 30 mesh coal were made with amounts of calcium carbonate, iron oxide, and sodium carbonate equivalent to two parts by weight of the corresponding oxide to 98 parts of coal. These mixtures were carbonized at 915° C., 815° C., 725° C., 630° C., and 525° C., under the same conditions as with the coal alone. The weights of charges employed were such that each charge contained 30 lbs. of coal.

The calorific values, in B.Th.U. per c.ft., of the gas made from the blends with sodium carbonate (76 lbs. Na_2CO_3 per ton of coal) were lower than from the coal alone, but the volumes and calorific values in therms per ton of coal were appreciably increased at all temperatures of carbonization above 600° C. The improvements in gas volume ranged between 9 p.ct. and 24 p.ct., and in therms between 3 p.ct. and 12 p.ct. The rates of gas production at all stages of carbonization with the retort at 915° C. and 815° C. were greater with the mixture containing sodium carbonate than from the coal without addition. With the retort at 725° C. and 630° C., however, sodium carbonate had little effect on gas production during the earlier stages of carbonization, but the volumes of gas evolved, relative to the amounts from coal alone, were greater during the later stages.

The addition of calcium carbonate caused an increase of 11 p.ct. in the volume of gas made per ton of coal with the retort at 915° C., and an increase in total thermal value of the gas of 5 p.ct.; and the rates of gas production at all stages were greater than with coal alone. When carbonization was carried out at 815° C., or at lower temperatures, the yields of gas and tar were approximately the same with and without calcium carbonate.

The increase in gas volume at 915° C. with iron oxide was 6 p.ct., and the total thermal value was improved by 2 p.ct. With the retort at 815° C. and lower temperatures, the volumes of gas made per ton of coal were increased, but the yields of gas expressed in therms, and the amounts of tar produced, showed little change.

The quantities of sulphuretted hydrogen in the crude gas were reduced as a result of the addition of the three compounds; iron oxide was most effective in this respect, and sodium carbonate was least effective.

The amounts of ammonia produced were greater with the mixtures with the inorganic compounds at all temperatures of carbonization above 700° C.; the largest increase, about 35 p.ct., was obtained with calcium carbonate at 915° C. With the retort at 630° C., the yields of ammonia with the mixtures were little more than half the amount from the coal alone; but at 530° C. the added compounds made little difference to the production of ammonia.

The nature of the changes which occur in the process of carbonization as a result of blending the coal with the three inorganic compounds employed is discussed in the report.

COKE—PHYSICAL STRUCTURE, REACTIVITY.

The cokes made when different sizes of coal were carbonized at 915° C. and 815° C. were similar in appearance and strength to the corresponding cokes made at 980° C. (*vide* Sixteenth Report). Below 800° C. the cokes became less robust as the temperature of carbonization was lowered. The semi-coke prepared at 344° C. was removed from the retort in a condition of size similar to that of the coal, 8 to 30 mesh, carbonized. These cokes produced from blends of coal and coke were more friable than the products from coal alone. Below 700° C., calcium carbonate and sodium carbonate added to the coal before carbonization reduced the strengths of the cokes. Iron oxide rendered the cokes more friable at all temperatures below 900° C.; at 630° C. and 525° C., no appreciable binding of the particles occurred in the mixtures with iron oxide.

At the end of the report, a brief account is given of work in progress with the object of determining the relative ignition temperatures, reactivities towards steam at 1000° C., and towards carbon dioxide at 900° C., of the cokes made during the investigation. The experiments so far conducted (Tables V., VI., and VII.) have shown that lowering the temperature of carbonization from 980° C. to 915° C. caused increases in the reactivities towards steam and carbon dioxide, but had no effect on ignition temperature. The cokes obtained by the carbonization at 915° C. of mixtures of coal with calcium carbonate, iron oxide, and sodium carbonate were more reactive towards steam and carbon dioxide, and were more easily ignited, than coke from coal without addition. Calcium carbonate, iron oxide, and sodium carbonate increased the reactivity towards steam in ascending order as named; but as regards their effect on ignition temperature and reactivity towards carbon dioxide, iron oxide was less powerful than calcium carbonate.

TABLE V.—*"Ignition Temperatures" in Oxygen.*

Temperature of Retort, °C.	Test No.	Substance Added to Coal.	Ignition Temperature, ° C.
980	A to H	..	420
915	1 to 7	..	420
,,	8 and 9	Coke	420
,,	10	Calcium carbonate	375
,,	11	Iron oxide	400
,,	12	Sodium carbonate	345
815	13 to 17	..	335
,,	18 and 19	Coke	410
,,	20	Calcium carbonate	335
,,	21	Iron oxide	345
,,	22	Sodium carbonate	310
725	23 to 26	..	370
,,	27	Coke	380
,,	28	Calcium carbonate	360
,,	29	Iron oxide	360
,,	30	Sodium carbonate	340

TABLE VI.—*Reactivity of Cokes with Steam at 1000° C.*

Temperature of Retort, °C.	Test No.	Substance Added to Coal.	Steam Decomposed, P.Ct.
980	A to H	..	77
915	1 to 7	..	84
,,	8 and 9	Coke	84
,,	10	Calcium carbonate	92
,,	11	Iron oxide	95
,,	12	Sodium carbonate	98

TABLE VII.—*Reactivity of Coke with Carbon Dioxide at 900° C.*

Temperature of Retort, ° C.	Test No.	Substance added to Coal.	Carbon Dioxide Reduced, P.Ct.
980	A to H	..	13
915	1 to 7	..	17
,,	10	Calcium carbonate	40
,,	11	Iron oxide	31
,,	12	Sodium carbonate	65

The ignition temperature of coke from coal carbonized alone at 815° C. was 85° C. lower than the coke made at 915° C., and 35° C. lower than the coke made at 725° C. The addition of sodium carbonate lowered the ignition temperature of the cokes prepared at 815° C. and 725° C.,

but iron oxide and calcium carbonate produced little change.

It has already been mentioned that the addition of sodium carbonate to the coal before carbonization produced larger increases in the volume and thermal value of the gas made at high temperature than resulted from either the addition of calcium carbonate or iron oxide, and that calcium carbonate was more effective than iron oxide. It is worthy of note that the relative powers of these three compounds in reducing the ignition temperature and increasing the reactivity towards carbon dioxide of the resultant cokes are in the same order. On the other hand, the reactivity of the coke towards steam was improved most by sodium carbonate and least by calcium carbonate, iron oxide occupying an intermediate position. In this particular, the compounds stand in the same order as their relative powers in increasing the volumes of hydrogen evolved on carbonization of the coal. Attention is directed to these observations as indicating the probability that the fundamental reactions which account for the influences of the three compounds on the process of carbonization of coal also explain the changes which result in the reactivities of the cokes produced.

Discussion.

Mr. T. F. E. RHEAD (Birmingham): I should like to pay a tribute to both Dr. Parker and Mr. Wood for their very painstaking work. We feel that we are getting now a solid foundation on which to build our arguments and deductions concerning carbonizing problems; we are knocking the "ifs" and "buts" out of the arguments. I notice that Dr. Parker gets the maximum tar yield at 630° C. I am not sufficiently *au fait* with the Report to know whether he has determined the absorbable spirits in the gas in this connection, but I think, if he has not already done that, it would be quite a useful piece of work, because it is largely wrapped up with the condensation and enrichment problems of water-gas manufacture in verticals. I am also interested to know that, with the mixtures containing 10 and 20 p.ct. of coke, he cannot find any appreciable increase or decrease in thermal yield or tar yield. I am particularly interested because, in carbonizing briquetting mixtures of cokes and coals in vertical retorts, although they were briquetted when they went into the retort, they collapsed and became practically non-briquetting in the retort, so that they are similar to those with which Dr. Parker has been working. I rather suspect that we got a reduced thermal yield under these conditions, but I would not like to say that I am sure, because it might have been due to awkward working rather than to the actual mixture of the coke with the coal. A theory which it seemed to me might partially explain the possibility of getting reduced thermal yield is that, by increasing the heat conductivity by the addition of coke, you surround the particles of coal undergoing carbonization by a somewhat higher temperature than is ordinarily the case, and you may possibly get an increased cracking of the hydrocarbons given off by these particles of coal.

Mr. H. HOLLINGS (London): Reference has been made in the Twentieth Report to the blending of the Nottinghamshire coal, which I gather has not very strong caking properties. Dr. Parker made a very clear and a very proper reservation in the conclusions drawn, and I should just like to express the hope that in due course further experiments will be made with a more strongly caking coal, in order that wrong conclusions may not be drawn from the work described in this Report.

The PRESIDENT: I am very glad you have brought out that point, Mr. Hollings, because it occurred to me, especially having in view some of our Welsh non-caking coals, that it is a point worth keeping in mind.

Mr. HAROLD E. COPP (Hull): I am very glad to have an opportunity of saying a word or two about the Report, as I am a member of the Committee. I think you will all agree that this Report is a monumental record of industry, patience, and perseverance on the part of the investigators. It may possibly be said by some that the practical results obtained are hardly commensurate with the volume of work done. I entirely differ from that view, because I submit that a wide area of ground has been cleared for future investigation. With regard to the grading of coal, it has been shown that, although the size has very little effect on the number of therms obtained per ton, it has a very distinct effect on the rate of carbonization; this being, of course, slower, especially in the first stages, with a smaller coal than with a larger one. I think this point may be disregarded to some extent, because nowadays we all deliberately choose those coals from which the evolution of gas is rapid. It would point to the advisability, I think, of carbonizing smaller coal separately. It is noticeable that the volatile matter in the coke increases very rapidly as the temperature of carbonization decreases, but I am surprised to note that the specific gravity of the tar also decreases very rapidly with the lowering of the temperature. That, I think, should have an important bearing on what we hear so much about nowadays, *i.e.*, low-temperature carbonization, because tar of low gravity is an absolute nuisance, and is very difficult to handle or distil. Some time ago I used systematically to mix a certain proportion of breeze with a certain coal, and, although the Report does not bring out the point, my experience was that, with a highly caking co l, *i.e.*, a highly bituminous coal, there is a very distinct advantage in the admixture of a certain amount of breeze. There again, of course, the difficulty has been overcome by the proper choice of coal. With regard to the addition of inorganic compounds, the principal point is that they increase the rate of evolution of gas. That is particularly marked in the case of sodium carbonate. There is another point which is important, and that is that the H_2S has been reduced in each case. In a works of the size of those with which I am connected, I can make out that perhaps a very distinct saving in the cost of purification would be effected by the admixture of some inorganic compounds. Another very tangible result of this investigation is the lowering of the temperature of ignition of coke. This is one of the things we are after. If we are going to establish a market for smokeless fuel—and we are hoping at some time or another to get hold of some of the vast trade which would be held out to us if the use of coal in open fires were reduced—the reduction of the ignition temperature of coke is a very important matter.

Dr. PARKER, replying to the discussion, said: I must thank you for the kind way in which you have received the Report, and for the very encouraging remarks made, particularly by Mr. Rhead and Mr. Hollings. I am sorry that, owing to the lateness of the hour, the discussion has had to be closed so soon, because I know that one or two gentlemen here have tried the effect of size of coal upon the rate of carbonization in full-scale horizontal retorts, and I should have liked to hear what they had to say. May I suggest, however, that they should record their experiences in writing and send them to the Institution as written contributions to the discussion, because any figures they may have would be very useful as a guide to the Research Committee in its future work.

The PRESIDENT: I was going to suggest that. If any members who have information would do it we should be very glad.

Dr. PARKER: Mr. Rhead has pointed out that the maximum tar yield was obtained at 630° C., and has asked about the absorbable spirit. I take it he is referring to the amount of spirit which might be removed from the gas by washing with oil, or the use of active carbon, or other similar adsorbents. That we have not actually determined by the use of adsorbents, because, as you will readily understand, with a small test plant and intermittent retorts, we should have to fit up apparatus specially for it, and, therefore, points of that kind have been deferred. Mr. Rhead mentioned his experience in connection with the mixing of coke breeze with coal, and apparently he obtained lower thermal yields. Several speakers have referred to this blending, and there is just one thing I should like to stress in connection with it. We must differentiate between the carbonization of mixtures containing coke in continuous vertical retorts and in horizontal retorts, for the two conditions differ considerably in many respects. In continuous verticals, you may be steaming the charge, and if briquettes are made with coke breeze and the briquettes break up, you have probably the disadvantage of sending the steam round the wall of the retort and not through the charge. There are a number of factors like this, and I should like to discuss them with Mr. Rhead privately, in order to get a detailed knowledge of the conditions, because these do affect the results. Briquetting we have not tried yet, and there is a footnote in the Report pointing this out. Another remark I should like to make—and this also answers Mr. Hollings—is that we have put in italics the words "with the particular coal of moderate coking properties." We realized that the results of the highly-caking coal blending with coke may be quite different, and, according to our programme, the next coal to be employed will be a highly-caking coal.

Mr. Copp has referred to the low specific gravity of the tar made at low temperatures, and mentioned that the specific gravity decreased rapidly as the temperature of carbonization was lowered. This was not altogether unexpected. We claim that the work is a systematic study of the specific gravities of tars obtained at eight different temperatures, from high temperature down to the very lowest. Our friends who carbonize coal by low-temperature processes claim high values for these low-temperature low-gravity tars. I do not want to discuss this point, but some of us may differ in our opinions from those expressed by low-temperature carbonizers. Mr. Copp also referred to blending with coke breeze, and said he had obtained advantages in the case of highly bituminous coal. Again, I should like to ask if he was using continuous vertical retorts or horizontal retorts, because this affects the problem. He referred also to general questions of the admixture of inorganic compounds, the reduction of sulphuretted hydrogen, and the ignition temperature of coke, and with the views expressed by him I agree entirely. I gathered that he has some more notes, and I should be very pleased if he would let me have them after the meeting.

The PRESIDENT: If Mr. Copp has these notes, we shall be glad to have them; perhaps they can be included in the discussion as published.

ECONOMIC ASPECTS OF HIGH PRESSURE DISTRIBUTION.

By STEPHEN LACEY, B.Sc., Assoc.M.Inst.C.E., Distributing Engineer to the Gas Light and Coke Company.

Gas undertakings are periodically faced with a problem which in general terms can be stated as follows:—The increasing gas consumption by existing consumers and/or the prospective addition of new consumers makes it necessary to lay a main to the district in which the deficiency that has to be anticipated will occur. What should be the diameter of the new main, and what compressing plant, if any, must be installed to provide driving power sufficient to give the main of the selected diameter the required carrying capacity?

Such a problem may be resolved into two parts. First, estimates have to be made for a number of years ahead of the maximum rate of demand that should be provided for, and of the variation in rate of demand throughout the year. Secondly, an answer has to be found to this question:—Given the length of main, the maximum rate of gas delivery, the variations from that rate, and the terminal pressure required in the main, what is the economic combination of the diameter of main and the initial pressure?

The primary object of this paper is to show how the question given as the second part of the problem can be satisfactorily dealt with. It is true that the practical difficulty of estimating the rate of increase in gas consumption, &c., is often so great that it may be said that any precise calculation based on such uncertain foundations is a wasted effort. Nevertheless, there are cases, in long distance transmission for example, where the data can be defined with reasonable accuracy; and in many instances a systematic analysis on the lines suggested will help the experienced engineer in the exercise of his practical judgment.

Definitions of "High Pressure" and "High Pressure Mains."

Confusion often arises from the use of the terms "high pressure" and "low pressure." There is no well recognized line of demarcation between them. Therefore the author would have avoided the use of "high pressure" in the title of this paper if he could have found a practical alternative, especially because to many, "high pressure" will suggest pressures of not less than, say, 10 lbs. per sq. in. In this paper "high pressure" means any pressure greater than the maximum allowable in mains from which consumers are ordinarily supplied without the use of service governors, and the author fixes this limit at 8 in. or thereabouts.

Incidentally, it should be said that in connection with the use of formulæ for the calculation of the rate of flow in pipes, the term "high pressure" is confined to instances where the difference of pressure between the ends of the main in question is so considerable that the consequential change in density of the gas should be taken into account in the flow formula.

For differences of pressure between the ends of the main up to, say, 1 lb. per sq. in., the difference in the rates of flow as calculated from the high and low pressure formulæ respectively is negligible in practice, but for the sake of uniformity, the high pressure formula (see Appendix 1) has been used throughout this paper.

Again, the term "high pressure main" is commonly used in two quite different senses. It is applied to mains designed to supply gas at high pressure as, for instance, for high-pressure lamps or high-pressure furnaces. In such cases, the loss of pressure due to gas flow must be kept within narrow limits, *i.e.*, only a small part of the initial pressure in the main is available for overcoming resistance to the flow of gas. On the other hand, the term "high pressure main" is used—and this is the more common use—where the greater part of the initial pressure in the main is required for overcoming the resistance to the flow of gas throughout the length of the main. In this paper "high pressure main" is used in the latter sense. It is assumed that the mains are to be designed for filling holders at a distance and/or as feeders to "low pressure" mains. Throughout the paper, the terminal pressure of the main is taken to be 8 in. (water gauge), a pressure that corresponds to an absolute pressure of 15 lbs. per sq. in. when the atmospheric pressure is 29·9 in. of mercury.

Determination of Economic Combination of Diameter of Main and Initial Pressure.

Given, for a particular case, the length of main, the terminal pressure, the maximum rate of gas delivery and the extent and duration of variations from that rate—the most economical combination of diameter of main and initial pressure can be determined by a process of trial and error. The initial pressure required for the maximum rate of gas delivery is calculated for a number of mains of different diameters, and for each combination of size of main and initial pressure the annual main costs and pumping costs are determined. The most favourable combination will obviously be that for which the sum of main and pumping costs is the minimum. The pumping costs will vary with the number of hours of pumping, which will depend upon the variations in the rate of gas delivery throughout the year. Examples 1, 2, and 3 set out in the Table on the next page illustrate the method.

The figures relating to main costs and pumping costs in the table are based on assumptions set out in the Appendices. Amendments of the assumptions will probably be necessary when applying the method to actual cases, but the broad conclusions arrived at in this paper will not be thereby invalidated.

Appendix 1 deals with the calculation of initial pressure, given the length of main, rate of gas delivery, and terminal pressure; Appendix 2 with main costs; Appendix 3 with H.P. required at the compressor shaft; Appendix 4 with capital costs and running costs of pumping.

It will be noted that for the length of main and rate of gas delivery chosen in Example 1 (10 miles and 50,000 c.ft. per hour, respectively), the most economical combination of diameter of main and initial pressure, assuming continuous pumping at the maximum rate of gas delivery, is 10 in. and 3·7 lbs. per sq. in., also that as the duration of the pumping per annum decreases, the economic initial pressure increases and the corresponding diameter of main decreases.

Example 2 in the table is designed to show by comparison with Example 1 the effect of increasing the rate of gas delivery for a particular length of main. In Example 2, the length of main is the same as for Example 1, namely 10 miles; but the rate of gas delivery has been increased twenty-fold, to 1 million c.ft. per hour.

It will be noted in Example 2 that the most economical combination of diameter of main and initial pressure, where pumping is continuous, is 36 in. and 2·2 lbs. per sq. in. respectively, as compared with 10 in. and 3·7 lbs. per sq. in. in Example 1. This comparison leads to the conclusion, not at all obvious, that for a particular length of main, the economic pressure decreases as the rate of gas delivery increases.

Example 3 is designed to show by comparison with Example 2 the effect of increasing the length of main without changing the rate of gas delivery.

Comparison of Example 3 with Example 2 shows that for a particular rate of gas delivery, an increase in the length results in a decrease in the economic diameter of main, and an increase in the initial pressure.

The diagrams (figures 1 and 2) have been prepared to give a comprehensive view of the effect of variations in the rate of gas delivery and length of main upon the most economical combination of initial pressure and diameter of

Given (a) Rate of Gas Delivery (b) Length of Main (c) Terminal Pressure	Example 1. 50,000 C.Ft. per Hour. 10 Miles. 8 In. Water Gauge.					Example 2. 1,000,000 C.Ft. per Hour. 10 Miles. 8 In. Water Gauge.					Example 3. 1,000,000 C.Ft. per Hour. 100 Miles. 8 In. Water Gauge.				
—	Diameter of Mains, In.					Diameter of Main, In.					Diameter of Main, In.				
	12	10	8	6	4	42	36	30	24	18	30	24	18	12	10
Initial gauge pressure— (Lbs. per sq. in.) calculated from (a), (b), and (c) and selected diameter. (Appendix 1)	1·8	3·7	9·0	24·8	86·0	1·2	2·2	4·7	11·3	30·4	27·0	54·1	120·8	352	550
Main costs— (Appendix 2)															
Capital cost of main, per yard £	2 0 0	1 12 6	1 5 0	1 0 0	0 15 0	12 0 0	9 0 0	6 15 0	5 0 0	3 10 0	6 15 0	5 0 0	3 10 0	2 0 0	1 12 6
Capital cost of main, total £	35,200	28,600	22,000	17,600	13,200	211,200	158,400	118,800	88,000	61,600	1,188,000	880,000	616,000	352,000	286,000
Annual main costs at 8 p.ct. £	2,816	2,288	1,760	1,408	1,056	16,900	12,670	9,504	7,040	4,928	95,040	70,400	49,280	28,160	22,880
Horse power required at compressor shaft— (Appendix 3)	12	24	50	105	206	160	290	590	1,210	2,400	2,220	3,290	4,730	6,840	7,800
Pumping costs— (Appendix 4)															
Capital cost of pumps, including building £	350	750	1,300	2,250	3,600	3,100	4,400	6,600	9,200	13,800	13,250	17,000	22,400	30,000	33,300
Interest and depreciation on pumps at 15 p.ct. £	53	113	195	338	540	465	660	990	1,380	2,070	1,987	2,550	3,360	4,500	5,000
Running costs per 1000 hours £	25	50	104	219	428	333	605	1,228	2,520	5,010	4,640	6,860	9,860	14,220	16,300
Total annual pumping costs—															
When pumping 1000 hours per annum £	78	163	299	557	968	798	1,265	2,218	3,900	7,080	6,627	9,410	13,220	18,720	21,300
" " 3000 " " £	128	263	507	995	1,824	1,464	2,470	4,680	8,940	17,100	15,900	23,130	32,940	47,200	53,900
" " continuously, 8760 hours per annum £	272	551	1,107	2,253	4,290	3,385	5,960	11,760	23,480	45,870	42,600	62,650	89,860	129,300	147,500
Total annual (main and pumping) costs—															
When pumping 1000 hours per annum £	2,894	2,451	2,059	1,965	2,024	17,700	13,940	11,720	10,940	12,010	101,700	79,810	62,500	46,880	44,180
" " 3000 " " £	2,944	2,551	2,267	2,403	2,880	18,360	15,140	14,180	15,980	22,030	110,900	93,530	82,220	75,360	76,780
" " continuously, 8760 hours per annum £	3,088	2,839	2,867	3,661	5,346	20,290	18,630	21,260	30,520	50,800	137,600	133,100	139,100	157,500	170,400
Total main and pumping costs—															
Per 1000 c.ft. When pumping continuously at maximum rate	..	1·56d.	..	..	..	..	0·51d.	..	..	..	..	3·65d.*	..	..	..

* For long-distance transmission, a single main could hardly be relied upon, and in such event provision of a reserve main would increase the cost per 1000 c.ft.

main. The curves in these diagrams have been based on the same assumptions as the examples in the Table.

The four curves in each diagram refer to rates of gas delivery of 25,000, 50,000, 200,000, and 1,000,000 c.ft. per hour respectively. The curves are applicable only to continuous pumping, but similar curves could be as easily constructed for any number of hours pumping per annum. Fig. 1 shows the relation between length of main and the economic initial pressure; fig. 2, the relation between length of main and the economic diameter. As the aggregated time of pumping decreases, the economic initial pressure increases, and the corresponding diameter decreases; and therefore the diagrams give minimum economic initial pressures and the corresponding maximum diameters of main.

The following example taken from fig. 1 will serve to illustrate the general relations deduced from comparison of the examples in the Table :—For a length of 40 miles, as the rate of gas delivery increases from 25,000 to 1 million c.ft. per hour, the economic pressure decreases from approximately 120 lbs. to 10 lbs. per sq. in., while the corresponding diameter increases from 4 in. to about 30 in.

It is interesting to note that the general conclusions reached provide a rational justification, on the one hand for the employment of relatively low initial pressures (under, say, 10 lbs. per sq. in.), for the feeder mains of distributing systems supplying large towns and their growing suburbs, and on the other hand for the employment of relatively high initial pressures in mains supplying a number of small towns and villages a considerable distance from one another.

The total main and pumping costs per 1000 c.ft. have been given in the Table for the most economical combination in respect of each of the three examples. It is particularly noteworthy that in each case, the cost per 1000 c.ft. would be only slightly increased if a diameter of main were selected greater than that corresponding with the minimum cost. The author would recommend the selection of the larger diameter where, as frequently happens, it is impossible to forecast accurately the ultimate limits in the maximum rate of delivery required from the main.

Assumptions with regard to Main and Pumping Costs.

In order to avoid unnecessary elaboration, a uniform basis has been adopted in the paper both for main and pumping costs.

The main costs have been calculated on the basis of cast-iron pipes laid under tar-sprayed macadam; conditions that could apply most appropriately to relatively low pressures (say 5 lbs. per sq. in. and under) in mains of 12 in. diameter and upwards laid in suburban districts. Steel will often be used in preference to cast-iron, but at present prices, the resulting percentage difference will not, as a

DIAGRAM SHEWING ECONOMIC INITIAL PRESSURES FOR CONTINUOUS PUMPING.

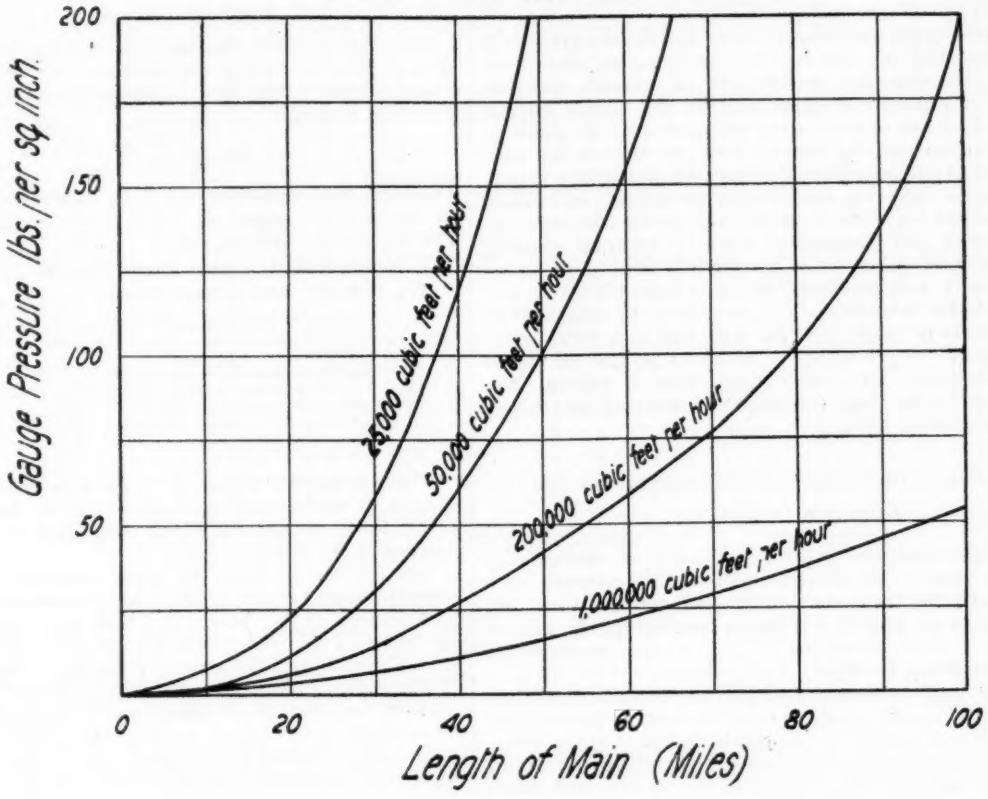


FIG. 1.

DIAGRAM SHEWING ECONOMIC SIZE OF MAIN FOR CONTINUOUS PUMPING.

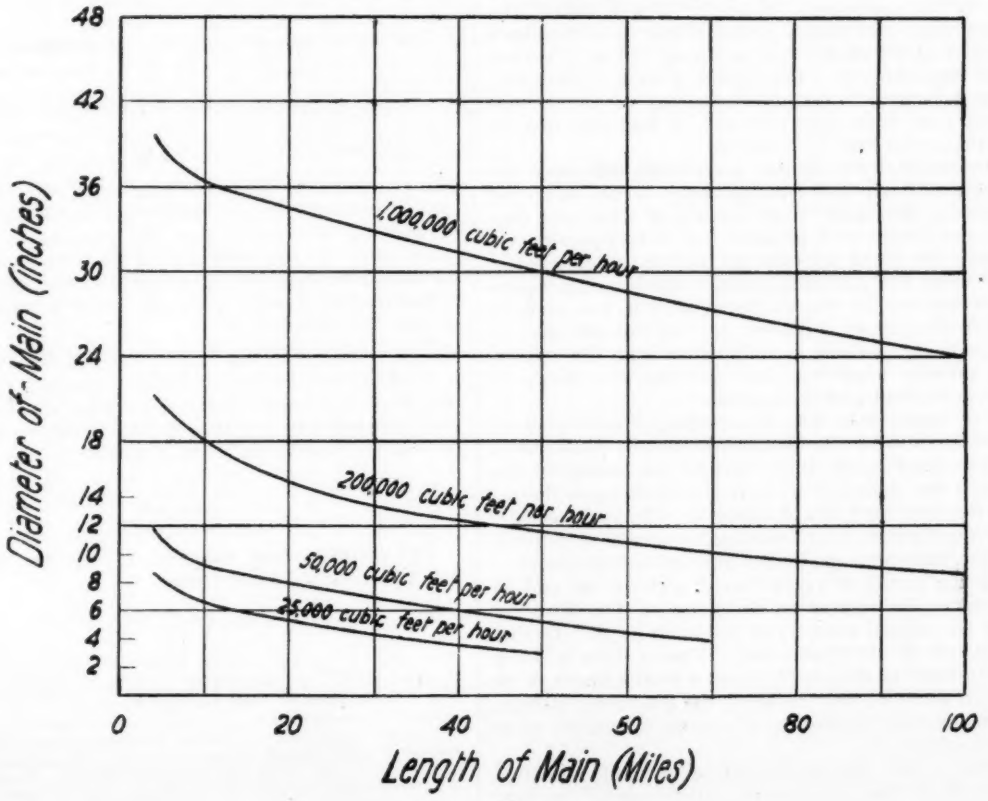


FIG. 2.

rule, be considerable; the variations in the cost of laying and reinstatement due to the character of the road surface broken up, will often prove to be of greater importance.

For the purpose of this paper, the capital cost of pumps and buildings and the running costs of pumping, have been calculated as set out in Appendix 4.

Variation in the capital costs from the figures given will be considerable, but this will not be found to affect substantially the economic combination of pressure and diameter in any particular case, because the annual charge in respect of the capital costs will generally be small in relation to the running costs. But variation in the running costs of pumping from the basis adopted in this paper, although not affecting the broad conclusions, will result in substantial amendment of the calculated economic initial pressure and diameter of main. The total running costs have been taken to be ½d. per H.P. hour at the compressor shaft, which corresponds, after some allowance has been made for attendance, &c., to a price of solid fuel to steam boilers of about 10s. per ton, and to a steam consumption of the prime mover of about 20 lbs. of steam per B.H.P. hour. It is recognized that in general, the latter figure is too high for large compressing plants and too low for small units.

Estimation of Maximum Rate of Delivery and Duration of Pumping.

The importance and practical difficulty of establishing a reliable basis for the determination of the economic combination of pressure and diameter were referred to at the beginning of the paper, and before concluding, the author thinks it advisable to comment briefly on this fundamental part of the whole problem.

It often happens that a high pressure main is needed to reinforce the supply to a partially developed district, for the time being adequately supplied, except at peak loads, by an existing system of mains. Therefore the main, when first laid, will be required to supply only the existing deficiency at peak loads (which incidentally, is often under-estimated), and afterwards to take up that part of the increasing consumption beyond the capacity of the existing mains. Before the most economical diameter of main and initial pressure can be determined in the way that has been described, it is necessary first to estimate the ultimate magnitude of the peak loads—this will give the maximum rate of gas delivery required of the main —and second to estimate the number of hours per year that pumping will be necessary. If a long view is taken, the diameter of main and initial pressure will be determined on the basis that the duration of pumping will be in excess of present requirements. The author would, in no case, accept as a basis for the determination of the economic diameter of main and pressure, a less duration of pumping than 1000 hours per annum.

It is obvious that the smaller percentage difference between the maximum and average rate of delivery, the better the duty obtainable from a main of which the diameter has been calculated as described in this paper, and consequently the lower the cost per 1000 c.ft. delivered in respect of main and pumping costs. The maximum rate of gas delivery can, of course, be reduced to the average rate by the erection of a holder, suitably located and of sufficient capacity, for use in conjunction with the system of mains directly supplying the consumers in the area where the additional gas is required.

It may be found that the annual charges in respect of the cost of erection of a holder, where that is practicable, will be more than compensated for by the saving in the annual main and pumping costs, consequent upon the reduction in the maximum rate of delivery. Or, alternatively, it may be found expedient to provide for a rate of delivery equal to the estimated maximum rate of consumption at the end of the period of years looked forward to, and to hold in reserve for unforeseen development, the power of increasing the annual capacity of the main by the erection of a holder, should the need arise. When a main is being designed to take up the supply from a works about to be closed down for economic reasons, the gasholder storage already in existence represents, of course, a valuable asset in this connection.

In conclusion, the author wishes to express his indebtedness to Mr. H. J. Escreet, Assistant Distributing Engineer of the Gas Light and Coke Company, for the great assistance he has rendered in the preparation of this paper.

APPENDIX 1.

Initial Pressure.

In every instance, the initial pressure (given the rate of flow of gas, the length and diameter of main and the terminal pressure) has been calculated from Unwin's High Pressure formula :

$$Q = 2675 \sqrt{\frac{d^5}{\zeta SL} \cdot \frac{p_1^2 - p_2^2}{p_a^2}}$$

the coefficient of friction, ζ, being evaluated as explained in the author's paper on "The Flow of Gas in Pipes" (Trans. I.G.E., Belfast, 1923).

This opportunity is taken of recapitulating the procedure.

The symbols used are as follows :

- Q = Flow in c.ft. per hour, gas at 60° Fahr., and 30 in. mercury.
- L = Length of main in feet.
- d = Diameter of pipes in inches.
- p_1 = Absolute pressure at beginning of pipe in lbs. per sq. in.
- p_2 = Absolute pressure at end of pipe in lbs. per sq. in.
- p_a = Atmospheric pressure in lbs. per sq. in.
- S = Specific gravity of gas as compared with air.
- η = Viscosity in C.G.S. units.
- ζ = Coefficient of friction.

The appropriate value of for any given set of conditions is determined from the diagram, fig. 3, account being taken of the degree of roughness of the internal surface of the main.

The full black line is the upper limit for "Commercial smooth drawn brass pipes" as determined by Stanton and Pannell (Phil. Trans. A., vol. 214, 1914), and may be taken as the lower limit for all pipes used in practice in the distribution of gases or liquids. The dotted line is based on experiments on cast-iron mains* made by the author, and has been taken for evaluating ζ for the calculation of initial pressures in this paper. The mains have been assumed to be clean. If it were necessary to anticipate corrosion, higher values of the coefficient of friction would have to be taken. (See paper (Trans. I.G.E., Belfast, 1923).)

The first step in the determination of initial pressures (P_1) for any particular set of conditions, is to calculate the value of Reynold's Criterion, = R, from $R = 0{\cdot}00481 \frac{SQ}{d}$.

The viscosity of gas, η, has been taken to be 0·000136 and the specific gravity, S, to be 0·5.

R therefore becomes $17{\cdot}7 \frac{Q}{d}$.

The subsequent procedure is as follows :

(1) Calculate R from $R = 17{\cdot}7 \frac{Q}{d}$

(2) From the diagram, select an appropriate value of the coefficient of friction, ζ.

(3) Use this value of ζ in $Q = 2675 \sqrt{\frac{d^5}{\zeta SL} \cdot \frac{p_1^2 - p_2^2}{p_a^2}}$

The process thus described may appear cumbersome. In fact, it presents little difficulty, and it has the great merit of keeping always in view the importance of correctly evaluating ζ (the coefficient of friction), and enables one to determine readily the possible limits of error in the determination of initial pressure that will follow inaccuracy in this evaluation.

The following example will serve as an illustration :

Find the initial pressure required to pump 1,000,000 c.ft. per hour of gas of 0·5 S.G., through an 18-in. diameter pipe 100 miles in length, the final pressure being 15 lbs. per sq. in. (absolute). The viscosity,

$$\eta = 0{\cdot}000136.$$

$$R = \frac{0{\cdot}00481 \times 0{\cdot}5 \times 1{,}000{,}000}{0{\cdot}000136 \times 18}$$

$$= 985{,}000 \text{ (approximately).}$$

The corresponding value of ζ from the dotted line in fig. 3 is 0·0043. Then from :

$$Q = 2675 \sqrt{\frac{d^5}{\zeta SL} \cdot \frac{p_1^2 - p_2^2}{p_a^2}}$$

$$P_1 = \sqrt{4{\cdot}218 \times 10^6 \times \zeta + 225}$$

$$= 135{\cdot}5 \text{ lbs. per sq. in., absolute.}$$

$$\text{Gauge pressure} = 120{\cdot}8 \text{ lbs. per sq. in.}$$

* These experiments were made on mains in use including a normal number of bends, and no addition was made to the net length in calculating the value of ζ from the results of the experiments. Therefore the values of ζ corresponding to the dotted line on fig. 3 may be taken as allowing for a normal number of bends in the length of a main.

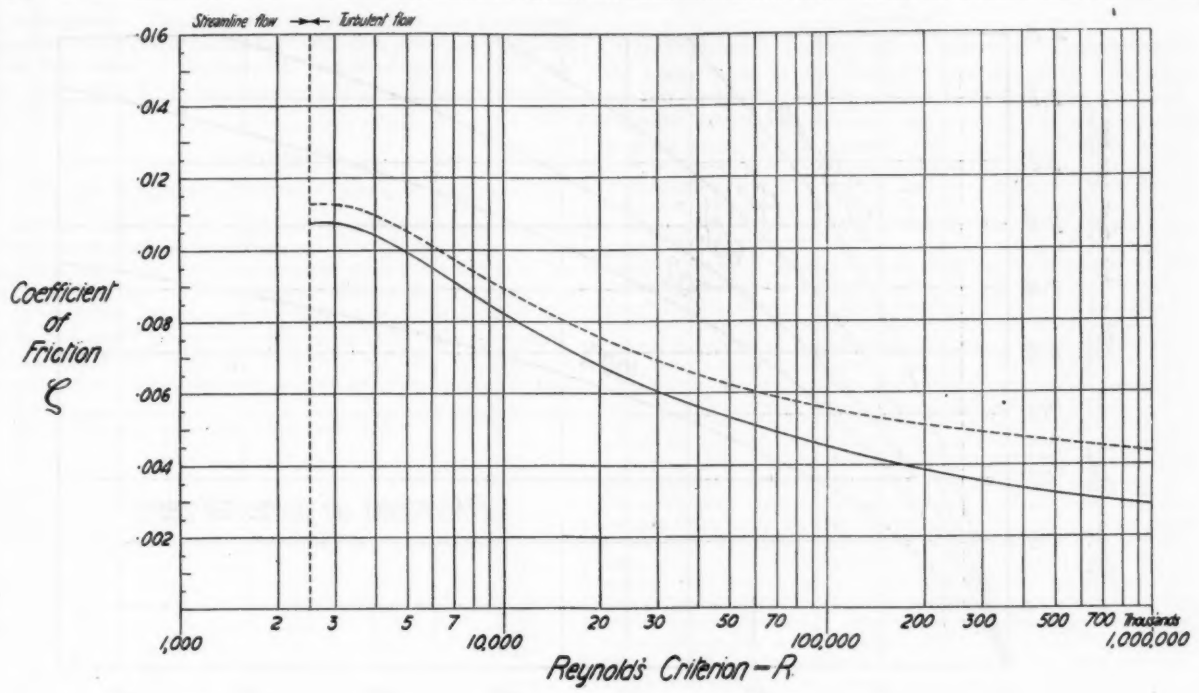


FIG. 3.

If instead of taking ζ from fig. 3 at the value of 0·0043, the value of 0·0060 is used, corresponding for the value of R in this example to a heavily corroded pipe, the value of P_1 becomes 159·8 lbs. per sq. in. absolute. Gauge pressure = 145·1 lbs. per sq. in.

On the other hand, if ζ were to be given the value of 0·0030, which would be applicable to a very smooth internal surface of main, the corresponding initial gauge pressure would be approximately 100 lbs. per sq. in.

Thus it will be seen how the method enables an estimate to be made of the increase in the initial pressure that will follow a progressive increase in degree of roughness of the internal surface of the main.

It will interest members to know that since 1923, other investigators of flow of gas in pipes have rejected the use of empirical formulæ only strictly applicable to conditions similar to those which the particular formula was designed to meet. In 1927 were published the results of an inquiry by German investigators*, who followed the same lines as the author, making the relation between Reynold's Criterion and the coefficient of friction the basis of their calculations. The same applies to an interesting paper presented this year by Lieut.-Col. Auld to the Institute of Petroleum Technologists, and entitled "Development Problems in the Exploitation of Natural Gas."

APPENDIX 2.

Cost of Mains.

The capital costs of the mains are calculated on the following scale :

Diameter of Main. Inches.	Cost of Pipes per Yard. (a)	Laying, per Yard. (b)	Reinstatement, per Yard. (c)	Total per Yard.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
3	0 3 4	0 5 2	0 4 0	0 12 6
4	0 4 4	0 6 8	0 4 0	0 15 0
6	0 7 1	0 8 11	0 4 0	1 0 0
8	0 10 1	0 10 5	0 4 6	1 5 0
10	0 14 4	0 13 2	0 5 0	1 12 6
12	0 17 8	0 15 10	0 6 6	2 0 0
14	1 1 7	1 0 11	0 7 6	2 10 0
18	1 10 8	1 10 4	0 9 0	3 10 0
24	2 6 2	2 2 10	0 11 0	5 0 0
30	3 3 6	2 17 6	0 14 0	6 15 0
36	4 3 6	3 18 6	0 18 0	9 0 0
42	5 5 9	5 9 3	1 5 0	12 0 0
48	6 11 3	7 18 9	1 10 0	16 0 0

(a) Cast-iron pipe (B.S.S. Class A) at £8 per ton, plus 10 p.ct. for special castings.
(b) Includes laying, cartage and all other costs, except pipes and reinstatement.
(c) Tar sprayed macadam, 6s. per square yard, with an addition for extra hardcore on diameters above 10 inches.

The annual main costs are taken to be 8 p.ct. of the capital costs. The 8 p.ct. covers interest, depreciation, and maintenance.

* Report on the Investigations carried out by the Special Committee on Distribution by Pipes of the Deutscher Verein von Gas- und Wasserfachmannern. Dr.-Ing. R. Biel, 1927.

APPENDIX 3.

Horse-Power Required to Compress 1000 c.ft. of Gas Per Hour to the Initial Pressure Required in the Main.

The figures in the first table of this paper under the heading "Horse-Power Required at Compressor Shaft" have been based on compressor efficiencies on an isothermal basis of 50 p.ct.

The efficiency of compression, in fact, varies substantially with the type of compressor and with the pressure and rate of gas delivery, and it is thought that the following notes may be useful as indicating the extent to which the basis adopted for this paper would require to be modified in specified conditions.

The work required for isothermal compression, *i.e.*, when the heat generated by compression is removed from the gas as generated, is the minimum by which the compression can be effected. The horse-power required in these conditions can be calculated from the expression :

Horse-power to compress 1000 c.ft. of gas per hour

$$= 2{\cdot}46 \log_{10} \frac{p_1}{p_2}$$

where the absolute pressure in lbs. per sq. in. is raised from P_1 to P_2. The horse-power corresponding to isothermal compression for initial gauge pressures in the main from 0 to 150 lbs. per sq. in. and from 0 to 15 lbs. per sq. in. are shown graphically by the curves marked 100 p.ct. in figs. 4 and 5; and the other curves on the same diagrams show the horse-powers required at efficiencies from 40 p.ct. to 70 p.ct., which represent, approximately, the limiting efficiencies in practice.

The most economical type of compressor to use depends on the pressure required, and the volume to be compressed. For pressures up to 1 lb. per sq. in. (27 in. water gauge), a fan is the most economical form of compressor for volumes of 20,000 c.ft. per hour and upwards. The isothermal efficiency of compression is about 40 p.ct. to 55 p.ct. depending upon the pressure and volume and type of fan, but as these fans are high-speed machines, they can be direct coupled to a steam turbine or electric motor, and the overall efficiency of the set (in terms of lbs. of steam or units of electricity per 1000 c.ft. compressed) is relatively high.

For moderate volumes and pressures of 1 to 15 lbs. per sq. in., a rotary compressor of the exhauster type is suitable. There are two types of bladed rotary compressors available, the ordinary type worked at speeds up to 100 revolutions per minute, and the type with a freely revolving drum between the blades and the casing, which, by eliminating the rubbing of the blade tips on the casing,

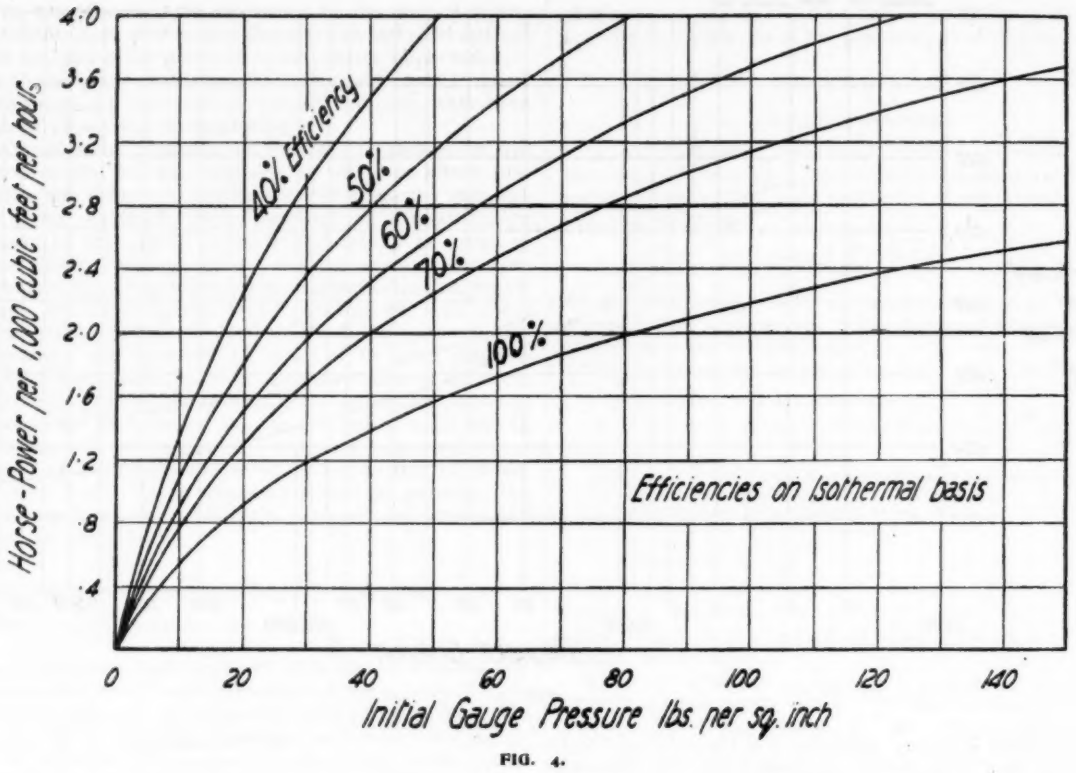


FIG. 4.

enables the machine to be run at speeds up to 1000 revolutions per minute. The efficiencies of both types vary between 45 p.ct. and 60 p.ct., but as the latter type is suitable for direct coupling to a high-speed prime mover, a greater over-all efficiency can be obtained with it than with the slow-speed type, which can only be driven by a reciprocating steam engine or through shafting and/or belts.

A reciprocating compressor has an efficiency of 40 p.ct. to 50 p.ct. for pressures up to about 25 lbs. per sq. in., and an efficiency up to 65 p.ct. for higher pressures. Generally, this type of compressor is not so economical as a high-speed rotary machine for pressures up to 15 lbs. per sq. in., excepting for very small volumes. For pressures above 150 lbs. per sq. in., the reciprocating is the only type of compressor that can be used. For pressures between 25 lbs. per sq. in. and 150 lbs. per sq. in. the efficiency is high, but for large volumes, the turbo compressor, dealt with below, gives a higher over-all efficiency, as it is suitable for direct drive by steam turbine or electric motor.

For volumes above 60,000 c.ft. per hour, the turbo compressor is a very suitable type of compressor for pressures from 1 lb. per sq. in. to 150 lbs. per sq. in. The efficiency of this compressor varies between 55 p.ct. and 70 p.ct. according to the pressure and volumes for which

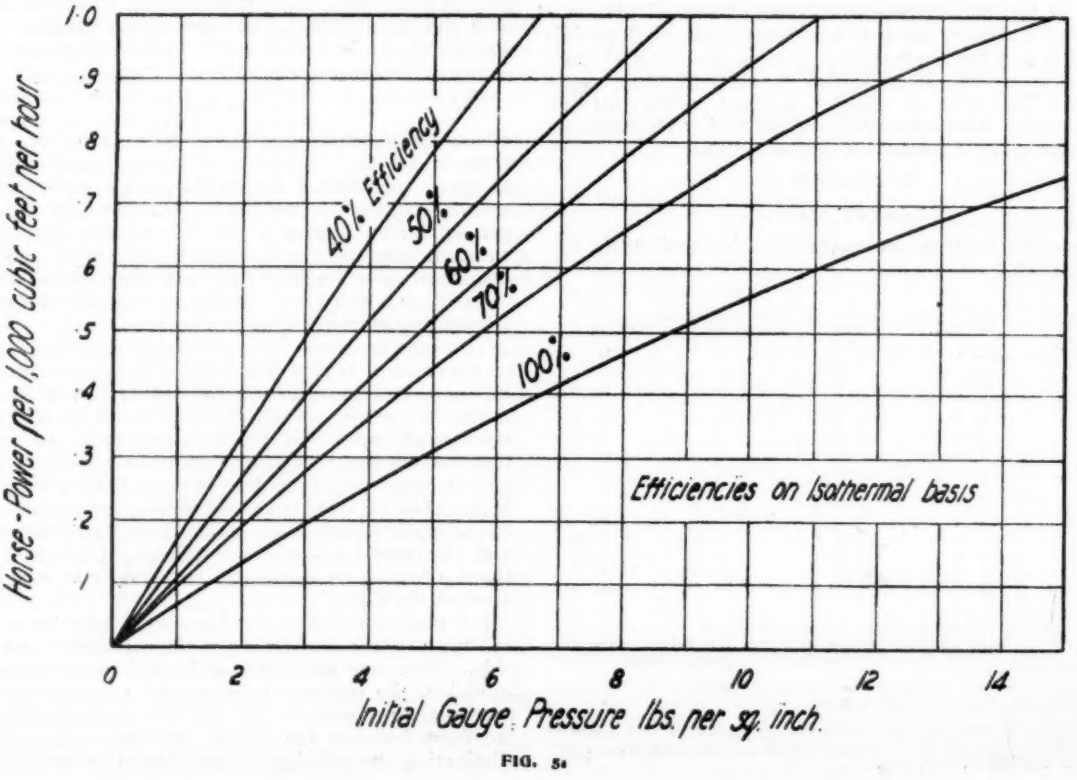


FIG. 5.

it is designed. The minimum volume which can be economically compressed increases with the pressure required from the value of 60,000 c.ft. per hour given above for low pressures, to about 500,000 c.ft. per hour at 100 lbs. per sq. in.

APPENDIX 4.

CAPITAL COSTS AND RUNNING COSTS OF PUMPING.

Capital Costs of Pumping Plant and Building.—The cost of pumping plant will vary not only with the horse-power required, but also, to a less extent, with the volume to be pumped and the initial pressure. But in drawing up the scale used for the purpose of this paper, the author has made the assumption that the costs will vary according to the total horse-power required without taking into account, separately, the two factors of initial pressure and volume.

The following scale has been adopted:

Total Horse Power Required at Maximum Delivery.	Cost of Pumping Plant (without Spare Plant).	Cost of Spare Plant.	Cost of Building.	Total Cost.
	£	£	£	£
25	250	250	250	750
50	500	500	300	1,300
100	900	900	450	2,250
200	1,800	900	800	3,500
300	2,400	1200	1,000	4,600
400	2,800	1400	1,200	5,400
500	3,200	1600	1,400	6,200
750	3,800	1900	1,700	7,400
1000	4,800	1600	2,000	8,400
2000	6,300	2100	4,000	12,400
3000	7,800	2600	5,500	15,900
4000	9,300	3100	7,000	19,400
5000	12,000	3000	8,500	23,500
6000	13,600	3400	10,000	27,000
7000	15,200	3800	11,500	30,500
8000	16,800	4200	13,000	34,000

For plants up to 200 H.P., it has been assumed that two units would be installed, one being spare to the other. From 200 H.P. to 1000 H.P. three units have been allowed for, two being required at full load and one spare; from 1000 H.P. to 5000 H.P. four units, three at full load and one spare. Above 5000 H.P., four units have been provided for full-load working, and an additional unit as spare.

The costs of plant in the Table are based on actual costs of steam-driven compressors of the stated horse-power, an approximate average cost of several types of compressors (with the appropriate prime mover) having been taken.

The costs of buildings should only be accepted as a rough guide, the cost having been taken at £10 per H.P. for the smallest building, reducing to £2 per H.P. for 1000 H.P. and upwards, and finally to £1 10s. per H.P. above 2000 H.P.

In arriving at the annual costs in respect of the capital costs of pumping plant and building, the charge for interest, maintenance and depreciation has been taken to be 15 p.ct. per annum.

Running Costs.—These have been calculated at ½d. per H.P. hour at the compressor shaft, including attendance, &c. For compressors driven by reciprocating steam engines, the lbs. of steam per H.P. hour may vary from 35 lbs. to 15 lbs. For turbine-driven turbo-compressors or fans, the steam consumption at full load will vary between 30 lbs. per H.P. hour for small units and 14 or 12 lbs. per H.P. hour for large units, where it is worth while going to considerable expense to achieve economical running.

With direct-fired boilers, the cost of steam may be taken at 15s. per 10,000 lbs., with fuel at 10s. per ton. The corresponding cost per H.P. hour will be:

	d.
At 30 lbs. steam per H.P. hour	0·54
At 14 „ „ „ „	0·25

The steam consumption of 20 lbs. per H.P. hour referred to on p. 892 corresponds to a cost of 0·36d. for steam, allowing 0·14d. for attendance, &c.

For gas-engine drive, the gas required per H.P. hour will vary from 19 to 25 c.ft. (500 B.Th.U.), or from 0·095 to 0·125 therm, corresponding to 0·38d. and 0·50d. per H.P. hour at 4d. per therm.

For electric drive with a motor of 90 p.ct. efficiency and current at 0·5d. per unit, the cost per H.P. hour is 0·41d.

Discussion.

The PRESIDENT: I should like to express my appreciation to Mr. Lacey for so kindly offering to read this paper. We were together many years ago at the Gas Light and Coke Company, when he first entered the industry; and I had a very great personal regard for his father. This paper is a most valuable one. I know that Mr. Lacey has made a large number of investigations into this matter; and here we have the fruits of his work, which involved a great deal of examination, experiment, and calculation. We in Cardiff have to transmit large quantities of gas; and until I went in for a big length of high-pressure main, I never realized what the horse-power of the engines really meant. When I discussed the matter some years ago with Mr. Lacey, he rather opened my eyes. The costs he gives are nearly the same as those which applied to my own case when pumping fairly large quantities over distances for a long time. Another matter to which I should like to draw attention is the importance of having gasholders in operation *en route*. If you can use holders in the districts served it is a very great help; and I should like to recall a remark made to me by the late Mr. Harry Jones when I went over the works with him only a short time before he died. He said he was going to erect holders all over the place in the outlying districts, fill them up during the hours of light demand, and use the gas from them during the hours of peak loads. I am glad to see that Mr. Lacey also refers to that practice. It is sometimes difficult to know what to do with regard to the size of mains. We had to lay a main to supply a rapidly growing district about six miles from Grangetown, and we studied the matter time after time. We had to pass the pipe under the main railway line and under four further sets of rails; but the greatest difficulty was that of negotiating the Llandaff Bridge. When we opened it, we found that we had a clearance of only ⅝-in. for the sockets of the steel mains to be dropped in. It was that which really governed the size of the main. We decided to use a 12-in. main and to provide the requisite power to pump the gas forward. You will have an opportunity of seeing that when you visit the works.

Mr. JNO. P. LEATHER (Letchworth): We are very much indebted to Mr. Lacey for again reading a paper on the question of distribution. All of us will remember the paper he read at our meeting at Belfast—a paper which will always be referred to by all who are considering questions of distribution, and particularly in cases where it is advisable to introduce higher pressures in order to get more gas delivered without increasing the size of mains unduly. Now he has added to that another very valuable communication, and one which will be very helpful indeed to those who have to consider high-pressure gas distribution. The paper is written tersely, yet clearly. It is evident that under certain conditions, if the quantity of gas to be distributed is increased, it is preferable to enlarge the mains and adopt a lower pressure rather than to use small mains and distribute at a very high pressure. It is good for us that our attention should be drawn to points such as this, so that in our various districts we may have the best possible combinations of main sizes and pressures. I think the members of the Institution as a whole are indebted to Mr. Lacey for putting this matter so clearly before us.

Mr. F. H. ROBINSON (Harrogate): Our thanks are due again to Mr. Lacey for having made an earnest endeavour to put this question on a really scientific basis. There has been quite a lot of rule-of-thumb work in the past, and anything which will result in its being dealt with more scientifically is welcome. Mr. Lacey rather suggested, in one part of his paper, the use of moderate pressures and larger mains for feeding into the low-pressure mains in the large towns, and higher pressures and smaller mains for the rural supplies; but I imagine there are few towns where that scheme could be carried out strictly. It would seem that some sort of compromise is required whereby medium-size high-pressure mains are laid to the outskirts of the town, with district governers, and then smaller mains, still at high pressure, continuing to the outlying villages. That is the problem we have to face at Harrogate. Our scheme is to run a belt line round the edge of the town, feeding wherever there is any deficiency of supply, and from that line we take out branches to the outlying villages in the very large area we have recently taken over. There is an area of about 120 square miles to supply.

Mr. LACEY: At what pressure?

Mr. ROBINSON: At present we are sending out at only 6 lbs., but the whole scheme is designed to go up to 25 lbs., so that we are keeping a reserve for developments. In Appendix 2 Mr. Lacey gives the cost of laying mains; and it appears to me that this cost is rather on the high side. Conditions will vary considerably in different places; but we have let a contract for laying six miles of main, and for the 4-in. section the all-in cost will not exceed 7s. 6d. per yard. I ought to explain, of course, that much of the length of main is being laid in the grass verge; but, even so, I think Mr. Lacey's figures are on the high side. They are perfectly safe figures for most conditions met with. Applying his method to our own conditions on a length of 8 miles of 6-in. main supplying one of the outside areas, I find the cost works out at 1·45d. per 1000 c.ft. Taking the figures given in the paper, the cost works out to about 2d. per 1000 c.ft., so that again the margin is on the right side.

Applying the Unwin formula, given by Mr. Lacey, to that particular main, with an initial pressure of 15 lbs. and a final pressure of 1 lb., the discharge is 33,972 c.ft. per hour. I have used the Oliphant formula hitherto, because it gives, if anything, the lowest discharge of all those that have been quoted previously. To my mind it is safe to do that, and, further, varying factors are employed in the formula to suit the different sizes of main. Applying the Oliphant formula to the same length of main, the discharge is 36,300 c.ft. per hour. So that there again Mr. Lacey has given us figures which are dependable, and which allow ample margin under ordinary conditions. The President has referred to the value of holders, and I am in perfect agreement with him. We have taken over five works, each of which has its own holder, and that is an important factor to us. We find that the maximum discharge per hour out of the works is approximately 10 p.ct. of the maximum day's output. In other words, without the use of a holder the trunk main for supplying these districts would need to be 2·4 times the size required if a holder were available to take up the peak load. A further advantage is that, when carrying out repairs, cleaning out valves, putting in branches, or doing any other work on the trunk main, there is no interruption of supply whatever, and there is no necessity to put by-passes in. Altogether, holders are most useful. At our last meeting in London, when Mr. Sumner's paper was discussed, I mentioned that we were supplying a place 15 miles away from the works, and that the pressure at the works was only 8 in. That is made possible by the use of these holders. Six miles from the works there is a small holder, and this relays the supply to the next holder, which is another nine miles further on. We maintain the uniform pressure of 8 in., and fill the holders during the quiet periods, so that their contents can be used during the times of peak load. The holders have enabled us to avoid adopting high pressure, though the pipe is laid as a high-pressure pipe. In conclusion, I should like to express my very best thanks to Mr. Lacey for his paper.

Mr. C. S. SHAPLEY (Leeds): I should like to add my thanks to Mr. Lacey for his excellent paper. It is one which I am sure we shall all keep and value, for I consider it to be almost a classic. Recently we at Leeds took over a small (40 million c.ft.) undertaking, and endeavoured to run it from our low-pressure system. We ran out two small feeder mains, one of 10-in. and one of 9-in., and coupled up also a 3-in. supply, and found that the pressure was dropping there 45 tenths during the period of the main peak load. In that particular area, which has not been properly developed electrically, the peak load is the Monday washing load. The cooking load is a very heavy one, but not so heavy as the washing load. There is also still a lighting load in that area, I am glad to say, and we are trying to maintain it. There is a 100,000 c.ft. holder there —quite a kettle—but by taking gas out of the mains during the slack periods with a very small fan, which is designed to pass only 20,000 c.ft. per hour, we found that we could balance the pressure up to the usual pressure in the district. We maintain just 3 in. right through the area. It was necessary to send out only 12,000 c.ft. during that washing period, and this actually boosted up the end of our existing main system long before we coupled up to the works. It really looks ridiculous that 12,000 c.ft. of gas per day will boost up the whole of the deficiency on a 40-million works.

The PRESIDENT: Was that on the far end of a main?

Mr. SHAPLEY: It was on the end of our system. In again thanking Mr. Lacey for his paper, I should like to say that I am sure I shall refer to it on many occasions in the future.

Mr. A. WILSON (Sydney): I am here as a seeker after knowledge, and not as a critic, and it is quite in keeping with my rôle that I should express thanks for the information given in the paper. I do want to express my thanks most heartily, for the paper is a monumental work. To-day I feel that I am the envy of all my colleagues in Australia, inasmuch as I alone out of the whole of them am sitting at the feet of Gamaliel. Mr. Lacey's last paper was read with extraordinary interest in Australia by myself and my colleagues, and it conveyed to us a wealth of information, which this particular paper supplements and, I imagine, must complement. It may be of interest to you to know that we in Sydney have a considerable measure of high-pressure distribution, inasmuch as we have an area of about 250 square miles of country, with a total main mileage of some 1850, out of which fully 300 miles of mains are carrying gas at what Mr. Lacey calls high pressure—*i.e.*, in excess of 10 in. Our maximum hourly output approximates to 3½ million c.ft., the necessary pressure at the works being some 200 in., exerted by steam turbine blowers of 1300 to 1400 H.P. The whole of the gas as it leaves our works is delivered at pressures ranging from some 30 in. during the early hours of the morning to 200 in. during the hours of the peak load. The long distance which the gas has to travel—approximately 25 miles in each of three directions—has presented a problem which has been extraordinarily difficult of solution; and I only wish that this paper by Mr. Lacey had been contributed some twelve or eighteen months ago, because it would have eased my anxiety very much in dealing with this particular problem. Our distribution system, like Topsy, has grown, and our troubles have grown with it. We think we have reached the economic, if not the practical, limit of distributing gas in the manner I have referred to, and we are to-day installing three, if not four, district gasholder and boosting stations, with storage capacities ranging from 2½ to 9 million c.ft. It may be of interest to you to know that I have already had district boosters without gasholders, picking up and sending forward considerable quantities of gas, approximating in one case to 250,000 c.ft. per hour, by step-up boosters, which have proved of incalculable value. Mr. Lacey referred to the fan type of boosting plant as being the most suitable. I have found fans to be very good, but there comes a time when they are a source of extreme danger in the distribution of gas in large volumes, particularly over large distances. With a fan, according to the characteristic curve, only at certain stated outputs will you get certain stated pressures. Our gas has to travel long distances. We have to maintain a minimum pressure at the extremity of 10 in., and ensure that the governors on the high-pressure and low-pressure systems will continue to function; and we have extraordinary difficulty in maintaining the requisite pressure. An attempt to increase the pressure at the works by means of fans has resulted in increasing the quantity beyond what was required in the district, with a consequent surging in the machine and a consequent drop in pressure; and owing to the inability to synchronize the requisite pressure with the quantity of gas required, we have recently gone in for positive machines of a peculiar and unique type. I am speaking of the crankless gas-engine driven booster, the invention of an Australian, Mr. Michell, of thrust-bearing fame. We have recently placed an order for seven machines, each of 300 H.P., with a capacity of 500,000 c.ft. per hour, the engines being made by the National Gas Engine Company, and the boosters by Messrs. George Waller & Sons. These machines are 8-cylinder gas engines, equal to 8-cylinder double-acting compressors. We have used machines of that character in Sydney for the past five years with extraordinary success. The flexibility of an engine of that type is such that you can get a variation of speed down to approximately 15 p.ct. of the normal. The controllability of such a machine and the ease with which it enables us to keep pace with the increasing and decreasing demands for gas in the district are remarkable. Inasmuch as it is gas-engine driven, we have the fuel at hand, we save the very large capital cost of steam boiler installations, and, though the running costs—particularly as gas is none too cheap in Sydney—may be a little high, the dependability of the machine outweighs the disadvantages. I should like to say, in conclusion, that papers of the character of this one stamps this Institution as the leader in the gas industry; and I do feel that I am exceptionally honoured in being able to listen to a paper from a master.

The PRESIDENT: We have with us to-day Senor Oliveira, from Rio de Janeiro, who has a very large territory to supply, and who has great difficulties in regard to distribution. We should much appreciate it if he would tell us some of his experiences.

Senor VICTOR PERDIGAO OLIVEIRA (Rio de Janeiro): I will just refer briefly to the extension of our distribution system in Rio. We have a compressor station, and we have to supply gas for a distance of 15 miles in one direction and 16 miles in another by means of a high-pressure system. Our daily output is 2500 million c.ft., and we start at the compressor house with a pressure of 22½ lbs. per sq. in. We distribute the gas through the high-pressure mains, through the regulators, and through the medium-pressure system, which extends for about five miles; the pressure in that latter system being reduced to 5 lbs. At that pressure we distribute the gas into several districts with large populations, and reduce the pressure to 6 in. in the consumers' mains. Perhaps I ought to add that we drive our compressors by electricity. [Laughter.]

The PRESIDENT: I have had an opportunity of seeing the maps and plans of the area of supply at Rio, and also some photographs which Senor Oliveira has brought here; and he explained to me what his system of distribution is. I am hoping that perhaps we may also hear more from Mr. Carder about it in the future. I must say that I have never seen such problems as they have to face at Rio. They have a mountain 3000 ft. high in the centre of their residential district. Perhaps at a later date Senor Oliveira may be able to give the Institution some more particulars of the great problems to be faced in South America.

Mr. LACEY: I do not think there have been any questions to which I need reply, but I should like to express my most grateful thanks to you for the very kind things that have been said of me. I am much indebted to the President, to Mr. Leather, and other gentlemen, and in particular to Mr. Wilson, of Sydney; it is certainly most gratifying to know that the work I have done has been of value to him.

EXTENSIONS AND MODIFICATIONS IN THE TOTTENHAM DISTRIBUTION SYSTEM.

By H. C. SMITH, M.Inst.C.E., Chief Engineer to the Tottenham District Light, Heat, and Power Company.

The aim of any progressive gas undertaking to-day is, or should be, to give the best possible service to its consumers. There sometimes seems to be a tendency to limit the meaning of the term "service" to the activities of those departments of the undertaking which are responsible for supplying the consumer with his appliances, and for periodically cleaning and adjusting them after installation.

The writer submits that good service does not consist merely of making it easy for consumers to obtain the appliances most suited to their needs, and of afterwards making regular examinations of them to see that they are functioning efficiently, but in every employee of the gas undertaking carrying out his duties in such a manner as to ensure that the consumer is supplied with gas at as low a price as possible, while conforming as nearly as is practicable with the following conditions:

(1) A constant quality and composition of gas.
(2) Freedom from any constituent in the gas likely to deposit, and thereby cause blockages.
(3) An adequate and even pressure of gas throughout each of the 24 hours.

It is sometimes rather disturbing to find that, while the costs of manufacturing gas are decreasing, the costs of selling it are increasing.

Any scheme for the inspection and maintenance of consumers' appliances, designed to deal with all the appliances on a district in a thorough manner, must of necessity be costly, whether paid for by consumers directly or paid for by them indirectly in the price of their gas. The details of such schemes, and the methods of paying for the work carried out under them, will necessarily vary according to the needs of different districts, but undoubtedly were the three conditions given above by the writer to be fulfilled, the work of an inspection and maintenance department would be very much reduced.

It is to engineers in control of works that one must look to see that conditions (1) and (2) are carried out.

Considerable assistance has been received in this work from papers and reports presented to The Institution of Gas Engineers, and to its affiliated District Associations.

It is with the third condition—an adequate and even pressure of gas throughout each of the 24 hours—that the writer proposes to deal in this paper, which describes some extensions and modifications in the Tottenham distribution system carried out in an endeavour to give every consumer an even pressure during the 24 hours.

The paper may be divided most conveniently into three sections:

(1) A description of the distribution system as it existed in the year 1925.
(2) The laying of additional trunk mains, and the installation of new boosting plant.
(3) Further extensions and modifications with a view to levelling-up pressures.

Growth in Output.

The chart shown in fig. 1 illustrates the remarkable growth of the Company since the year 1866. In that year the output of gas was 53,188,000 c.ft. During the year 1927, 17,298,995 therms, or 3,459,799,000 c.ft., of gas were distributed. Reference to the chart shows that the output of the Company was doubled every eight to ten years from the year 1899 until 1917.

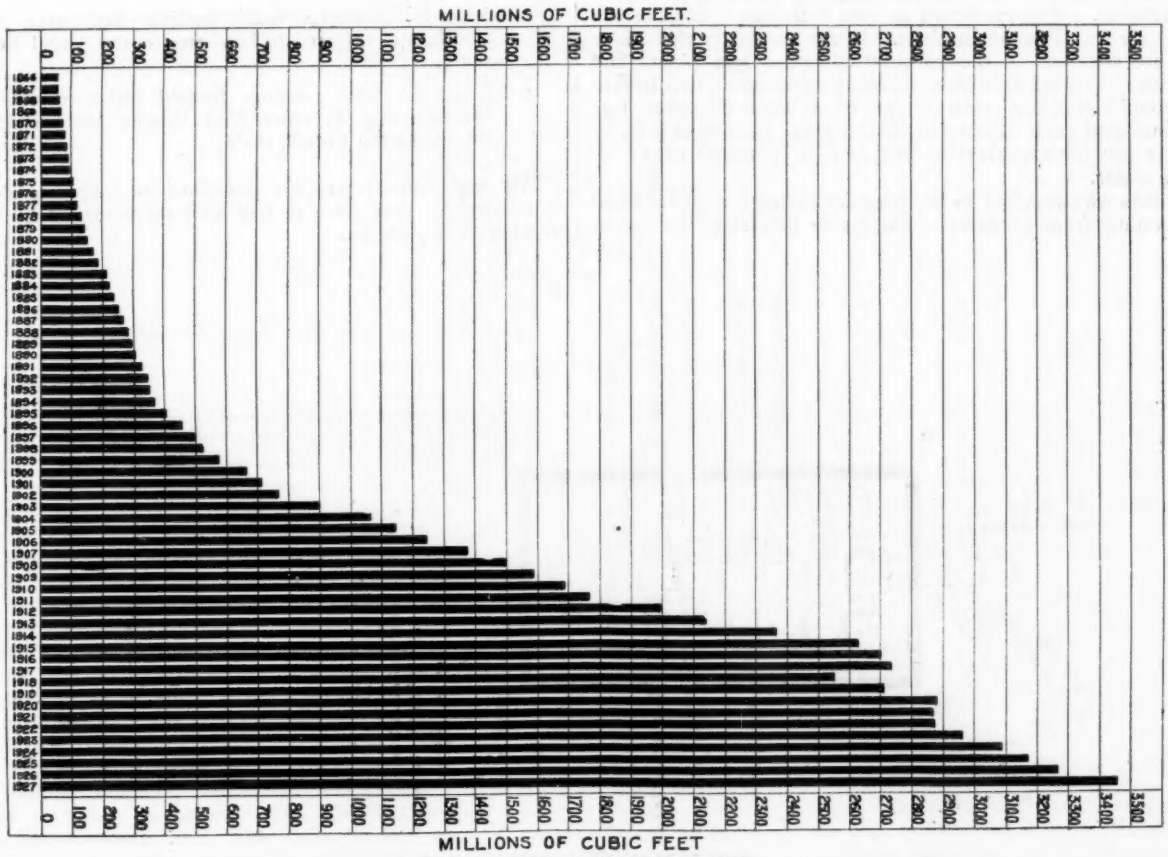


FIG. 1.—ANNUAL OUTPUT OF GAS.

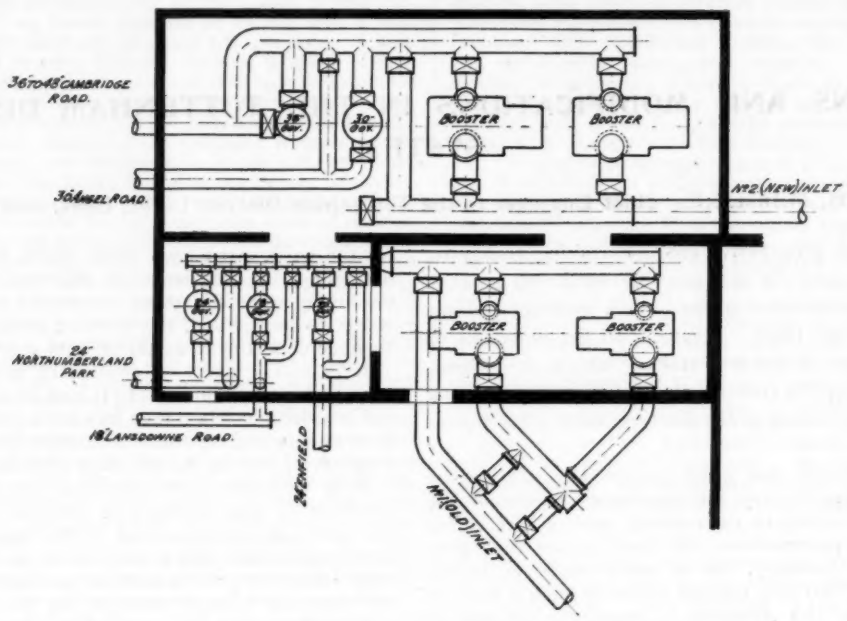


FIG. 2.—VALVE HOUSE.

In 1914 an amalgamation was effected with the Enfield Gas Company, which at the time of the amalgamation distributed 290,077,000 c.ft. annually.

(1) DESCRIPTION OF THE SYSTEM OF DISTRIBUTION PRIOR TO 1925.

For many years the weight of the gasholders was sufficient to provide ample pressure over the whole of the district, but with the advent of the gas cooker and the gradual development of heating peak loads, particularly the Sunday cooking load, the necessity arose for either increasing the capacity of the distribution mains or else increasing the pressure by mechanical means at the works.

The latter system was adopted, and boosting plant was installed. This consisted of two "Buffalo" fans driven by De Laval steam turbines. In the year 1917 these fans were removed to the carburetted water gas plant, and were converted into blowers, being replaced by two Bryan-Donkin boosters, each driven by a 250-H.P. steam turbine, and each capable of discharging 1½ million c.ft. of gas per hour against a difference in pressure of 43 in. of water.

Gas was supplied to the boosters through a 30-in. main running from a central valve-house illustrated in fig. 2, and was discharged from the outlet of the boosters into four trunk mains through Parkinson & Cowan water-loaded governors.

The connections in the booster and governor house are shown in fig. 3.

A plan showing the area of the district, together with the trunk mains previous to the extensions, is given in fig. 4.

The trunk mains were as follows:

1.—An 18-in. diameter main feeding South Tottenham, referred to hereafter as the Broad Lane main.

2.—A 24-in. diameter main feeding North Tottenham and Wood Green, referred to hereafter as the Northumberland Park main.

3.—A 30-in. diameter main feeding Edmonton and Southgate, referred to hereafter as the Angel Road main.

4.—A 24-in. main feeding Enfield either direct or through the Ponders End Works holders, and known as the Enfield main.

Although these mains are described as supplying definite districts, they were in fact all interconnected by the smaller supply mains.

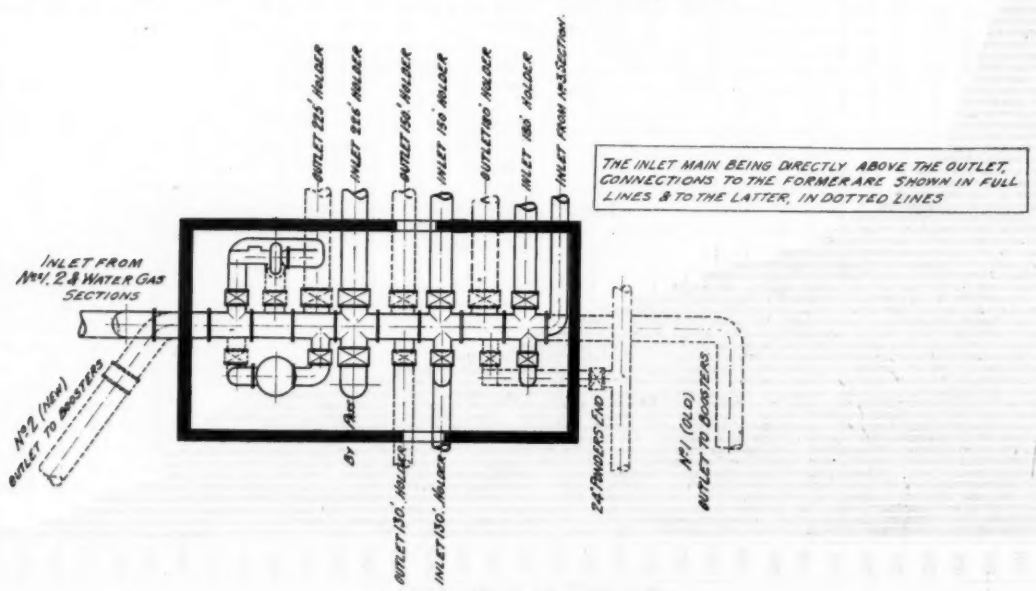

OUTLET 225' HOLDER
INLET 225' HOLDER
OUTLET 150' HOLDER
INLET 150' HOLDER
OUTLET 180' HOLDER
INLET 180' HOLDER
INLET FROM No 3 SECTION
THE INLET MAIN BEING DIRECTLY ABOVE THE OUTLET, CONNECTIONS TO THE FORMER ARE SHOWN IN FULL LINES & TO THE LATTER, IN DOTTED LINES
INLET FROM No 1, 2 & WATER GAS SECTIONS
No 2 (NEW) OUTLET TO BOOSTERS
No 3
No 4
OUTLET 130' HOLDER
INLET 130' HOLDER
24" PONDERS END
No 1 (OLD) OUTLET TO BOOSTERS

FIG. 3.—PLAN OF BOOSTER HOUSE.

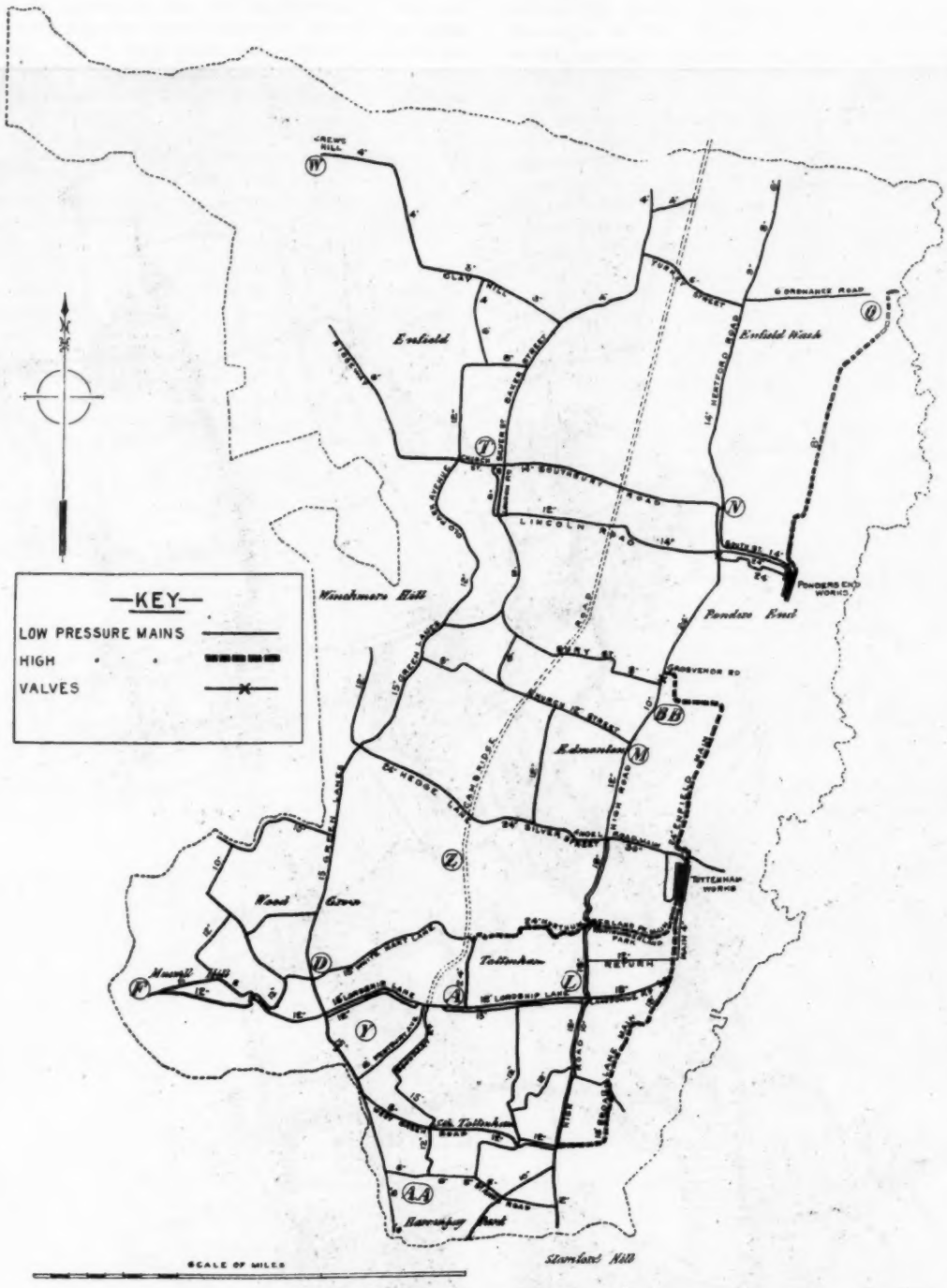


FIG. 4.—TOTTENHAM DISTRICT, 1924.

The 30-in. Angel Road main was tapped within a few yards of the works, and was treated as a low-pressure main. The remaining trunk mains were not tapped until over a mile or so from the works, and were looked upon as high-pressure mains. The term "high pressure" is used in this paper for convenience, but the maximum pressure referred to is one represented by a pressure increase of not more than 50 in. water gauge between the inlet and the outlet of the boosters.

The high-pressure trunk mains and the low-pressure Angel Road main discharged gas into the network of the distribution system at points which may be seen on reference to fig. 5, which gives a general idea of the system after the extensions to be described had been carried out. This is an illustration of a wire map designed by Mr. A. E. Broadberry when Chief Engineer to the Tottenham Company, and which has proved extremely useful on many occasions when distribution problems have been considered. The base of the map is an Ordnance map of the district to a scale of 6 in. to one mile. When a main is laid, pins are inserted in a vertical position in the map at suitable intervals along the route of the main. Wire of various gauges corresponding to different diameters of main is then soldered to the top of the pins and afterwards painted, all mains of the same diameter being painted the same colour. The result is a skeleton of the distribution mains laid over the Ordnance map and raised above it.

The wire map is not intended to take the place of the larger-scale plans of district mains; but during the preliminary consideration of schemes it is invaluable.

Reference has been made to the points at which the high-pressure mains discharged gas into the low-pressure system, and it should be made quite clear that this was a perfectly free discharge, there being no valves or district governors between the high-pressure and the low-pressure mains.

So long as the capacity of the high-pressure mains was sufficient to carry all the gas required to the points of discharge into the low-pressure mains at such a pressure

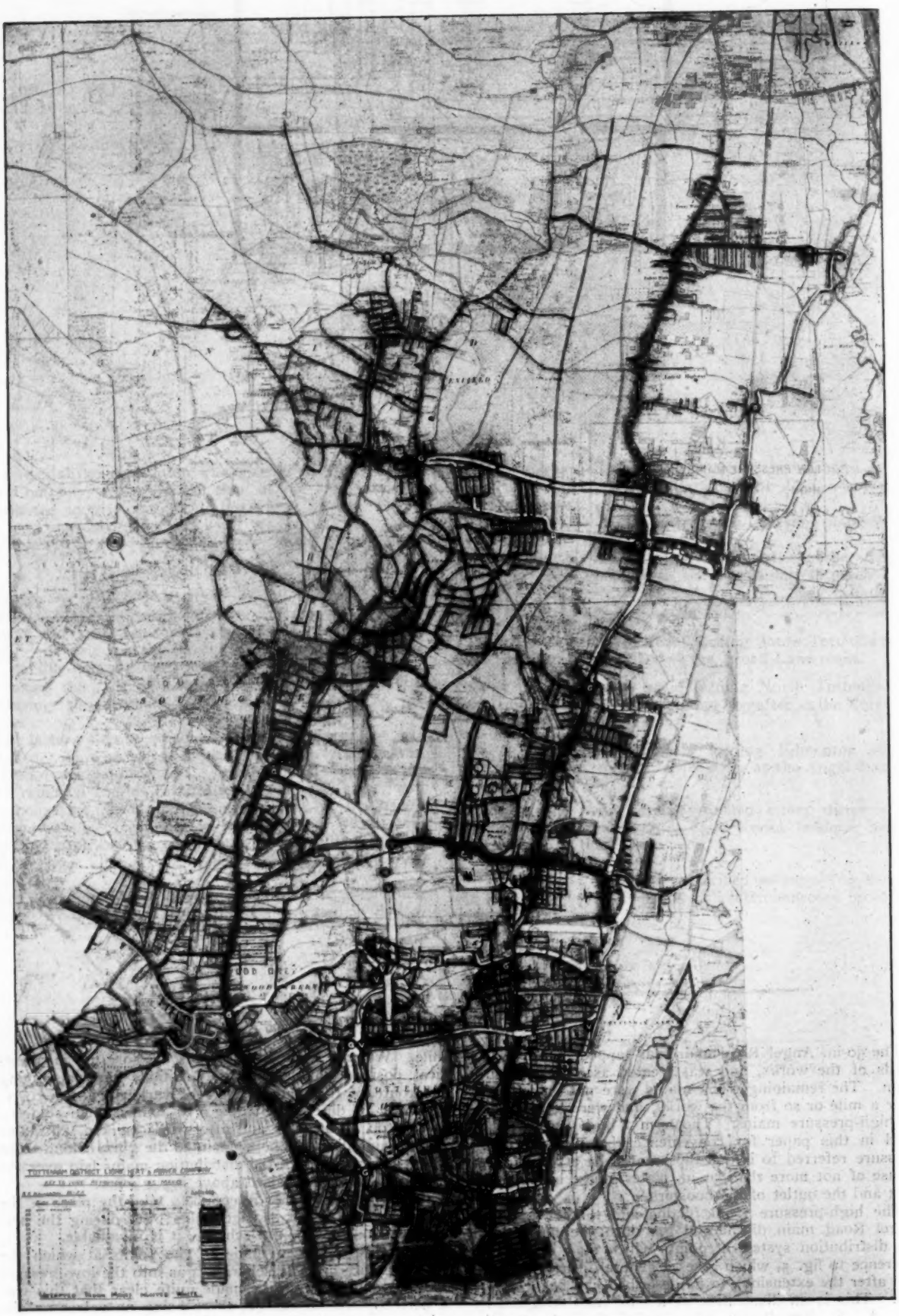


FIG. 5.—WIRE MAP OF MAINS.

as not to be excessive for the appliances of the consumers whose supplies were taken off nearest the point of discharge, and so long as the low-pressure system was adequate to distribute gas to the remaining consumers at a satisfactory pressure, this system worked well and was quite easy to control.

About the year 1900 it became evident that eventually the rapid growth of the district would necessitate the entire remodelling of the distribution system, but it was desirable to postpone this as long as possible, as at the time it was not quite clear where the future development would take place.

This postponement of the remodelling of the distribution system was made possible by the use of boosters. Boosting was only intended as a temporary relief, until the location of the future expansion could be more clearly defined.

About the year 1910 the construction of an arterial road was mooted; and as this road when constructed would render the remodelling a much simpler problem, this was postponed still further, in the hope that the construction of the road would not be long delayed.

The outbreak of war put a stop to the district expansion, which did not recommence until a few years after the war.

During the year 1924, however, it became obvious that it would not be possible to give a satisfactory supply without considerable alteration and extension to the system.

In the first place the boosters were working from 6.30 a.m. until midnight every day, with only two 1½-hour breaks; and during the maximum peak load hours they were working at full load. These boosters could have been replaced by others of larger capacity, as had been done in the year 1917; but though by this means more gas could have been distributed from the works, the pressures in parts of the district were too low to be considered satisfactory, and these low pressures could only be increased by giving consumers adjacent to the points of discharge of the high-pressure into the low-pressure mains, pressures not only higher than necessary, but, in addition, much higher than appliances were intended to work at.

By means of recorders fixed in a few consumers' premises a record was kept of district pressures. These consumers were provided with a supply of charts and arrangements made for the charts to be taken off every midday and posted to the works.

Pressure records were also taken at the various showrooms, and altogether seventeen charts were available at the works every morning showing the pressures at representative points on the district for the 24 hours ending midday of the previous day.

In addition, a 4-in. return main was run from the 10-in. main in the High Road, Tottenham (as shown in fig. 4), to the governor house at the works, and a record was kept of the pressures on this main.

From examinations of the district and return main charts the necessary information was obtained for controlling the loading of the station governors, or, at peak load times, the pressure on the outlet boosters, which was too high for the water seals of the governors, necessitating by-passing the latter. During these peak load periods gas was discharged into the Broad Lane main and the Northumberland Park main through the governor by-passes without any throttling whatever.

Fig. 6 shows the pressures on the outlet boosters, and fig. 7 the pressures in the district return main on a typical summer Sunday and also on a typical winter weekday.

Fig. 8 shows the pressures at the same times at the point marked "A" (on fig. 4) which was taken near to where the Northumberland Park main discharged into the low-pressure system.

While the variations in pressure were greater at point "A" than at any other point on the district, similar

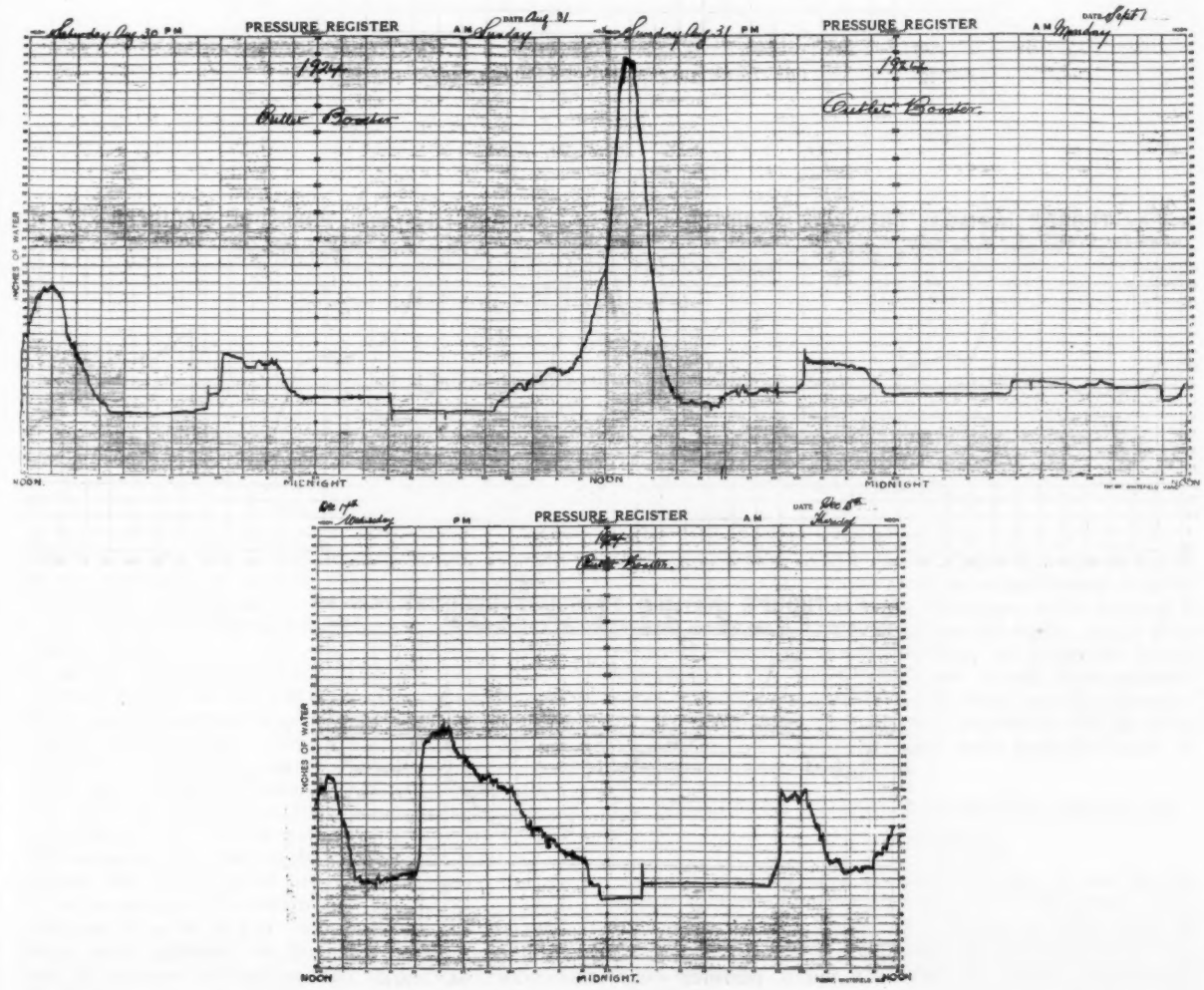


FIG. 6.—BOOSTER PRESSURES, 1924.

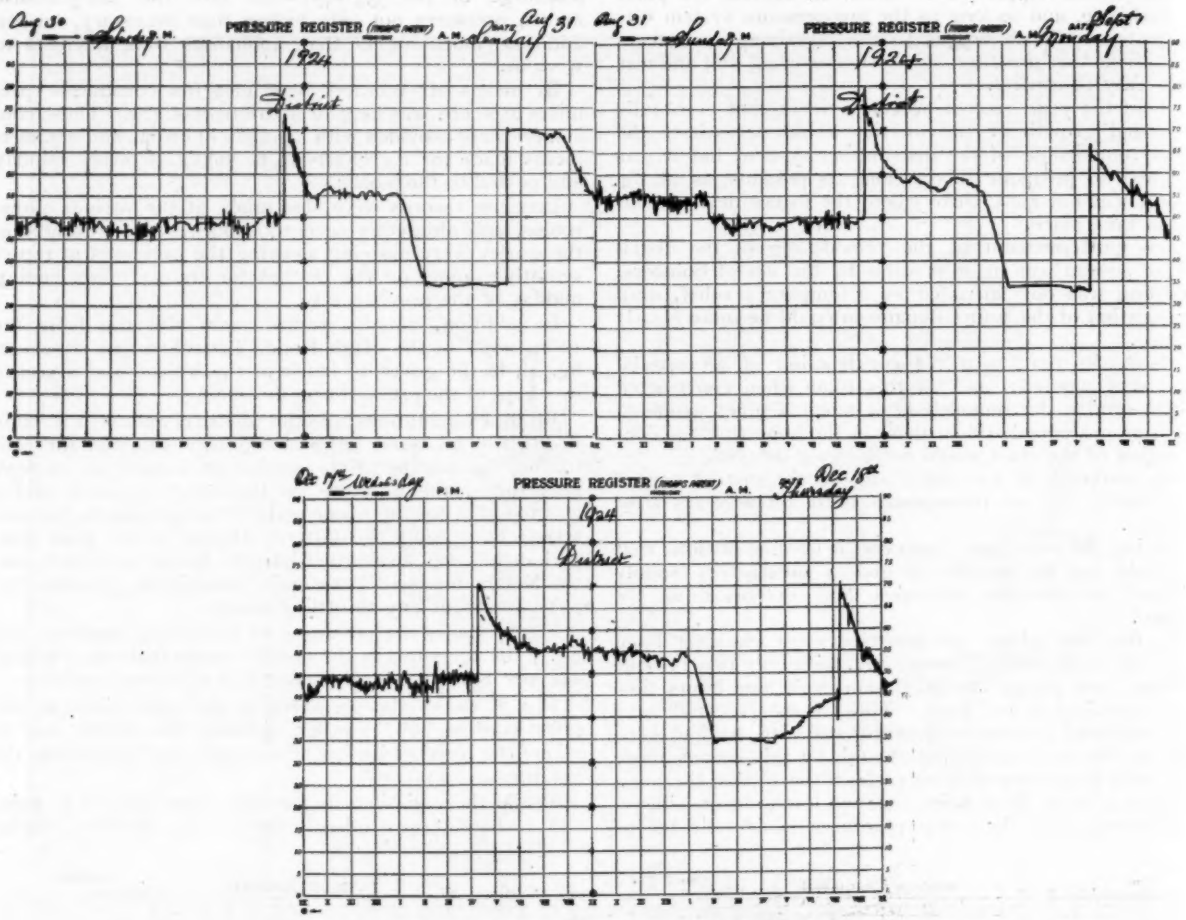


FIG. 7.—RETURN MAIN PRESSURES, 1924.

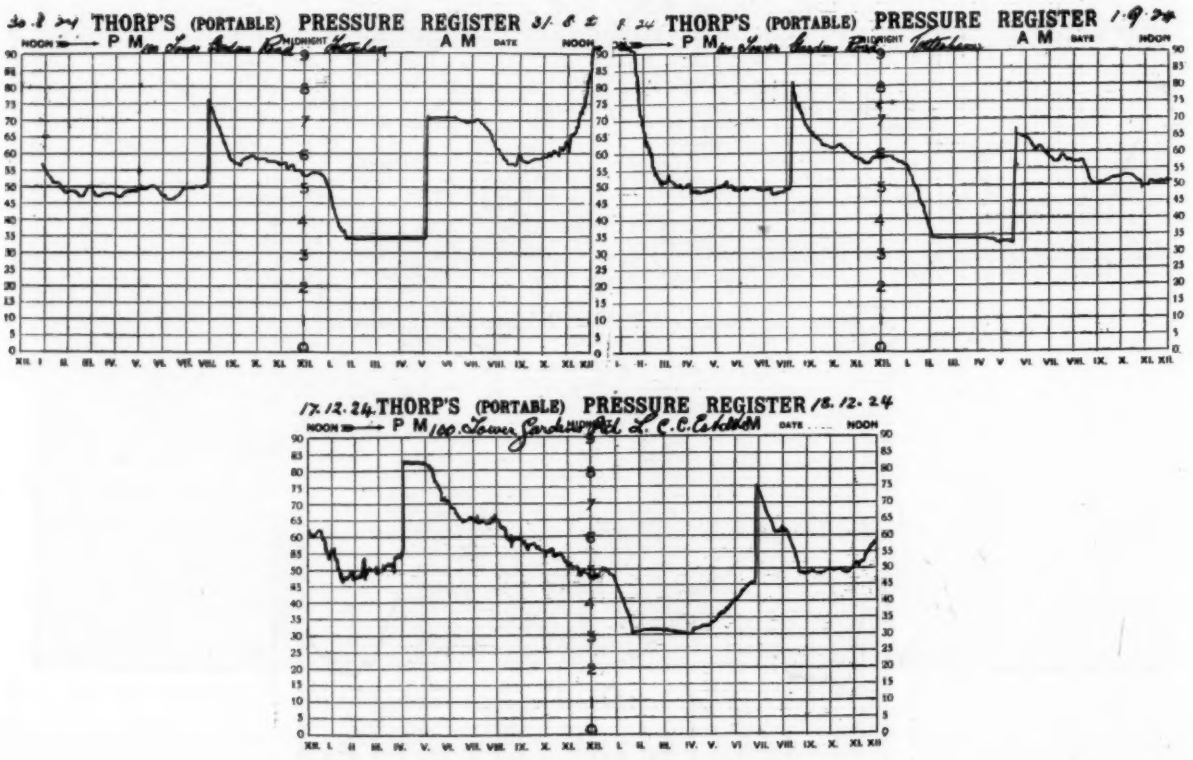
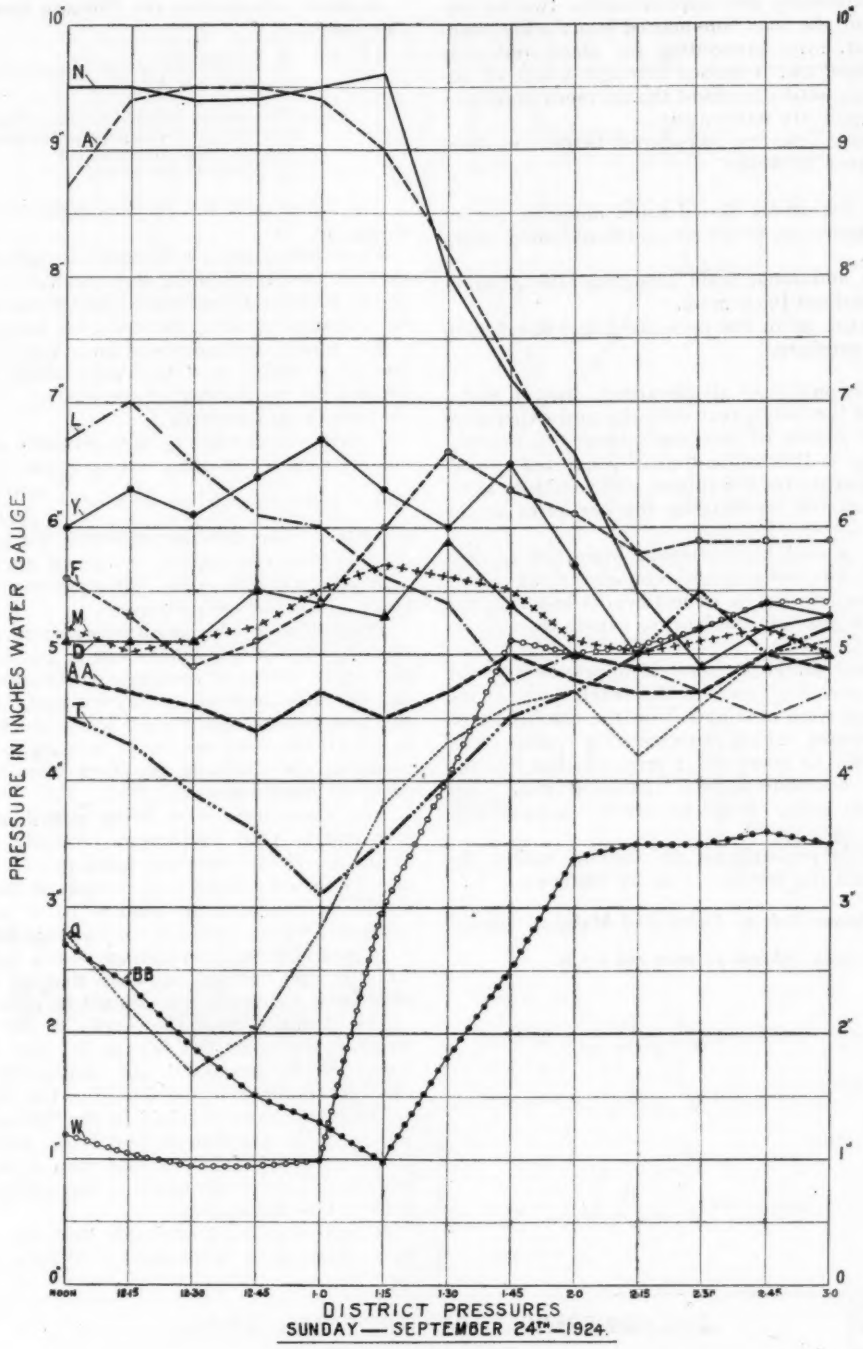


FIG. 8.—DISTRICT PRESSURES, POINT "A," 1924.



FOR POSITIONS OF POINTS REFERRED TO BY LETTERS ABOVE, SEE FIGURE 4.

FIG. 9.—DISTRICT PRESSURE VARIATIONS, SUMMER SUNDAY 1924.

variations were general, as will be seen in fig. 9, which shows the pressures at various points on summer Sundays during the cooking load. This was the most serious peak, but similar conditions obtained at other times only to a lesser degree.

The sudden increases in pressure during the morning and evening shown on the charts in figs. 7 and 8 were caused by a pressure wave which extinguished and lighted the public street lamps. These were fitted with the "Broadberry" apparatus, an excellent and economical appliance on a district which has mains of an ample capacity and on which a sudden increase of pressure of half-an-inch at the station governors will cause a wave of a like amount over the whole district. In the case of Tottenham the consumption of gas had increased so rapidly as to outgrow the distribution system, and a pressure increase of 4 in. to 5 in. was required at the works to give a wave sufficient to cause the necessary sudden increase in pressure of half-an-inch in the parts of the district farthest from the works.

An examination of all the available information to be obtained from the various pressure charts made it quite clear that to provide additional boosters, while making it possible to send more gas out from the works, could only do so if there were no objection to pressures being increased at the low-pressure end of the high-pressure mains. These pressures were seen to be too high already, and it was therefore considered imperative in the first place to lay an additional trunk main into the heart of the district.

(2) CONSIDERATIONS LEADING TO LAYING OF NEW TRUNK MAIN.

Several schemes were considered before it was finally decided to lay a 48-in. main from the Willoughby Lane Works to a point marked "Z" on fig. 4. This point is on the arterial road previously referred to (called the New Cambridge Road) which had now been constructed, and which ran through the district from south to north,

dividing it longitudinally into approximately two halves. At its southern end the road commenced in a thickly populated district, but, after proceeding for about one mile in a northerly direction, it passed through a belt of undeveloped country, until it crossed the northern boundary of the area of supply six miles away.

Three alternative schemes considered before the final decision was arrived at were :

(1) To replace the 18-in. Broad Lane main by one of larger capacity, or to lay an additional main along this route.
(2) To lay an additional main alongside the existing Northumberland Park main.
(3) To convert the 30-in. low-pressure Angel Road main into high pressure.

These three schemes were all discarded, Nos. 1 and 2 chiefly because of the very great difficulty and expense of laying additional mains of any size along the existing route, and No. 3, as this main, even if converted, would not leave much margin for the future, and would do practically nothing towards levelling-up the pressures in the southern area.

The laying of a real high-pressure main (as against boosted pressure) was not seriously considered, as it was felt that everything should be done towards lowering the pressure at which gas left the works, rather than of increasing it.

Calculations were made to ascertain approximately the quantity of gas carried by each of the trunk mains; and the necessary data were obtained from the conditions on Sunday, Sept. 7, 1924, which represented a typical cooking load. Between 12 noon and 1 p.m. on that day the quantity of gas distributed was 1,200,000 c.ft. For 15 minutes gas was going out at the rate of 1,500,000 c.ft. per hour.

From the loss in pressure on the various mains, the calculations showed the delivery to be as follows :

Approximate Maximum Rate of Delivery of Mains on Sunday, Sept. 7, 1924, between 12 noon and 1 p.m.

Main.		C.Ft. per Hour.
18-in. Broad Lane	$3550 \times 1025\sqrt{\frac{42}{0{\cdot}5 \times 11{,}740}}$	= 308,000
24-in. Northumberland Park	$3550 \times 2065\sqrt{\frac{41}{0{\cdot}5 \times 9{,}710}}$	= 674,000
30-in. to 24-in. Angel Road	$3550 \times 2550\sqrt{\frac{\cdot 2}{0{\cdot}5 \times 9{,}770}}$	= 183,000
24-in. Enfield	$3550 \times 2065\sqrt{\frac{10}{0{\cdot}5 \times 15{,}950}}$	= 260,000
		1,425,000

In these calculations the Chicago formula was used in the form :

$$Q = 3550 \times K\sqrt{\frac{h}{s \times l}}$$

where Q = quantity delivered in c.ft. per hour.
h = friction drop in pressure in inches of water.
s = specific gravity of gas (air = 1).
l = length of pipe in feet.

The value of K for varying diameters of pipe is given in fig. 10.

These calculations confirmed the opinion already formed that the new trunk main was required to relieve the Lansdowne Road and Northumberland Park mains, in addition, of course, to making provision for future growth.

The hourly consumptions on a typical summer Sunday and on a winter week-day were studied, and these were divided by the number of consumers. Fig. 11 illustrates the curves so obtained.

The most astonishing fact revealed was that the consumption per consumer between the hours of 12 noon and 1 p.m. on Sunday was only $\frac{1{,}200{,}000}{89{,}000}$ = 13·5 c.ft. per hour. This was not accounted for by a large number of industrial consumers, as out of an annual output of 3,086,480,000 c.ft., only 338,390,000 c.ft. were used by large and industrial consumers.

The following conclusion was arrived at : That, though the majority of consumers had a gas cooker, many also had other means of cooking, which were often made use of; but this condition would not apply in the majority of the new houses which were being erected on the district in which the only means of cooking provided were gas cookers. In addition, gas fires were being installed in many of these houses.

New consumers were being added at the rate of approximately 1800 per annum (actually 3050 were added in 1927). If each of these used 30 c.ft. between 12 noon and 1 p.m. on Sundays, the output at the end of ten years would be increased by 1800 × 10 × 30 = 540,000 c.ft. per hour, which, added to the existing output of 1,200,000 c.ft., would make a maximum hourly output of 1,740,000 c.ft. It was decided therefore that an hourly peak load of at least 2,000,000 c.ft. should be provided for.

The distance from the works to the New Cambridge Road as the crow flies is 7340 ft., and every likely route was carefully measured and considered, to ensure that the route finally selected should be the shortest possible.

The last trunk main laid in the Tottenham district was the 24 in. in Northumberland Park, which had been laid in 1882 and extended to 1906 (the 24 in. to Enfield was laid in 1914, in consequence of the amalgamation with the Enfield Gas Company).

It was considered advisable that the new main should be at least 36 in. in diameter. With a main of this dia-

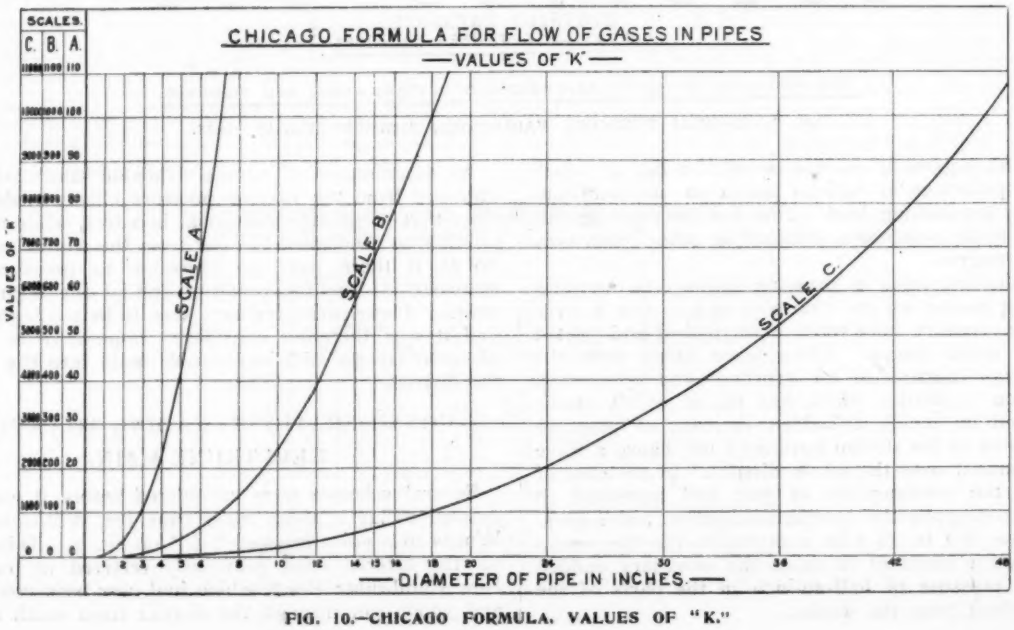

SCALES.
C. B. A.
CHICAGO FORMULA FOR FLOW OF GASES IN PIPES
—VALUES OF "K"—
VALUES OF "K"
SCALE A
SCALE B
SCALE C
1 2 3 4 5 6 8 10 12 14 15 16 18 20 24 30 36 42 48
—DIAMETER OF PIPE IN INCHES.—

FIG. 10.—CHICAGO FORMULA. VALUES OF "K."

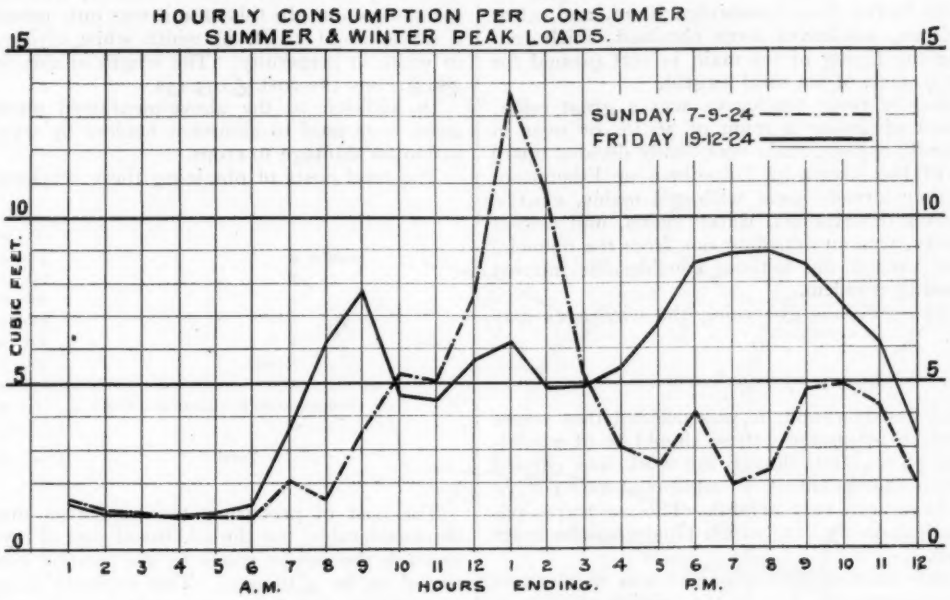


FIG. 11.—CONSUMPTION PER CONSUMER PER HOUR.

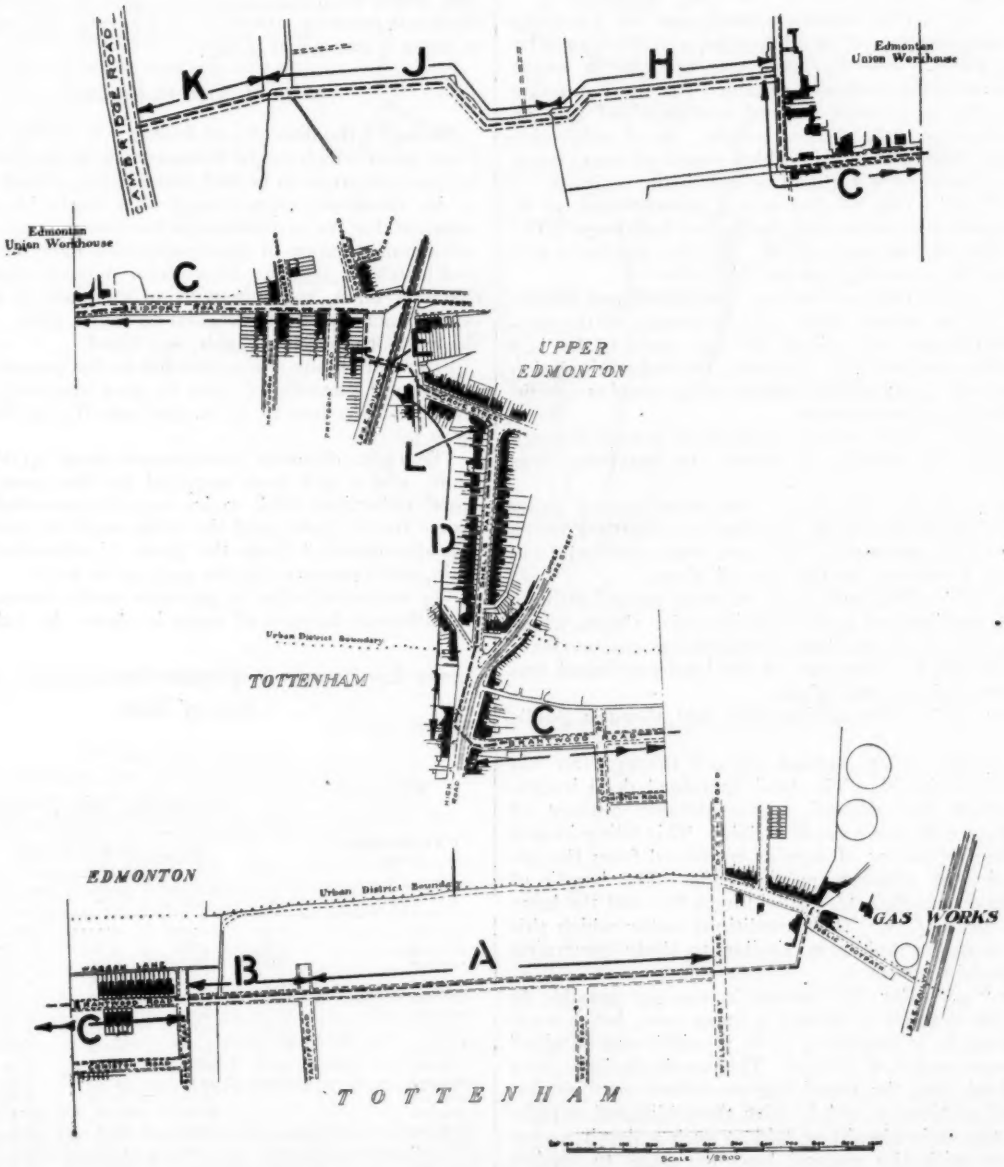


FIG. 12.—ROUTE OF 48-IN. DIAMETER MAIN.

meter it was highly important to select the shortest possible route. The route finally selected measured 9820 ft. from the works to the New Cambridge Road, and, after much negotiation, wayleaves were obtained which rendered possible the laying of the main in soft ground for 5030 ft. (over 50 p.ct. of the total length).

The obtaining of these wayleaves was a great relief, as the prospect of laying a main of 36 in. or over in diameter (actually a 48-in. main was finally decided upon) through any of the streets in Tottenham or Edmonton, crammed as they already were with gas mains, electric cables of various descriptions, water mains, and sewers of large capacity, was an appalling one from the financial point of view, though not without considerable interest as an engineering problem.

A few of the conditions governing the wayleaves may be of interest.

Conditions of Wayleaves.

After careful consideration, it was decided that where wayleaves were to be obtained these should be of a minimum width of 33 ft., and, though the work was carried out later without encroachment, an additional 2 or 3 ft. of width would have been very helpful. The wayleaves obtained are marked on fig. 12, which illustrates the route finally adopted.

A considerable amount of negotiation was involved in obtaining these wayleaves, but, in the opinion of all concerned, any trouble taken or expense incurred in this connection was amply repaid. The wayleaves are distinguished on fig. 12 by the letters "*a*" to "*k*."

Section "a."—This wayleave was over flat low-lying ground, consisting in part of allotments, and the remainder of playing fields. The wayleave was 1480 ft. in length and 33 ft. in width, and was obtained for the lump sum of £480. The agreement entered into provided that no building should ever be erected within 5 ft. of either side of the centre line of the main which would prevent, interfere with or hinder the right of access to the main.

Section "b."—This section was a private road 40 ft. in width bounded on either side by factory buildings. The length of this section was 445 ft., and the wayleave was obtained for the sum of £148 6s. 8d.

Section "c."—This section was laid through a private road serving an estate which was in course of development. Permission was given for the main to be laid through this road without payment, the only stipulation being that any good ballast recovered as surplus should be deposited on a site near by.

Section "d."—This section of the main passed through public roads, for which, of course, no wayleave was necessary.

Section "e."—In this section the main passed under the Enfield Town line of the London and North Eastern Railway; and a permanent wayleave was obtained from the Railway Company for the sum of £100.

Section "f."—This section of the main passed through a piece of undeveloped ground of irregular shape, which it was necessary to purchase outright, as no wayleave could be obtained. The area of the land purchased was 67½ perches, and the cost £250.

Section "g."—This section was laid through public roads.

Section "h."—This section passed through an old worked-out brickfield. The land contained deep irregularities, which necessitated a considerable amount of filling-in before the main could be laid. This filling-in was largely done by means of surplus recovered from the excavations in the adjacent public roads. The length of this wayleave was 840 ft., the width 33 ft., and the lump sum paid for it £387. The conditions under which this wayleave was granted were similar to those governing the wayleave in section *a*.

Section "j."—For this section it was not possible to persuade the owners to accept a lump sum, but a wayleave of 1070 ft. in length by 23 ft. in width was obtained for an annual rental of £16 4s. This wayleave lay across meadow-land, and the remaining conditions were similar to those of sections *a* and *h*, with the additional stipulation that the main should be laid at such a depth as not to interfere with the natural land drainage to ditches bordering the property.

Section "k."—This section passed through ground owned by an Urban District Council, who had laid it out for allotments. In this case it was only possible to obtain a wayleave of 12 ft. in width while laying, and 10 ft. in width in perpetuity. The length of this wayleave was 480 ft., and the cost £193 15s.

In addition to the above-mentioned payments, small sums were paid to allotment holders by way of compensation for damage to crops.

The total costs of obtaining these wayleaves were:

	£	s.	d.
Section *a*	480	0	0
,, *b*	148	6	8
,, *e*	100	0	0
,, *f*	250	0	0
,, *h*	387	0	0
,, *j* (say)	300	0	0
,, *k*	193	15	0
Compensation to allotment holders	83	4	6
Total	£1942	6	2

The cost of procuring the wayleaves may appear to be considerable, but the additional cost of laying the main through the public roads by the nearest route was estimated to be £10,399. This estimate is based on the assumption that the main could have been laid through the public roads in a straightforward manner. It was known, however, that many difficulties would have been met which would have proved costly to overcome. At a moderate estimate, therefore, the saving effected by means of the wayleaves was £8457.

Size of Main to be Laid.

Owing to the difficulty of finding a route for any further trunk main which might be necessary in the future, it was felt that the main to be laid immediately should be at least 36 in. diameter, even though this might be more than sufficient for the requirements for several years to come; but a consideration of the comparative carrying capacities and losses in pressure of a 36-in. diameter and a 48-in. diameter main, together with an estimate of the cost of laying each, led to a decision to lay a 48-in. main from the works to the New Cambridge Road.

From this point it was decided to lay a 30-in. diameter main for a distance of 3020 ft. in a southerly direction, and then to reduce to 24 in. for 2960 ft., as illustrated in fig. 13.

The 15-in. diameter low-pressure main up White Hart Lane, which had been supplied by the 24-in. diameter Northumberland Park main, was disconnected and connected to the 30-in., and the 24-in. main in Lordship Lane was disconnected from the 24-in. Northumberland Park main, and connected to the new 24-in. main.

The estimated drop in pressure under various loads of the different lengths of main is shown in Table I., the

TABLE I.—*Pressure Drop under Various Loads for Various Sizes of Main.*

Length of Main: 9820 Ft.

C.Ft. of Gas per Hour.	Pressure Drop. Inches of Water. Diameter of Main in Inches.				
	24	30	36	42	48
100,000	0·91	0·325	0·1412	0·0685	0·0336
200,000	3·63	1·30	0·565	0·274	0·1344
300,000	8·2	2·92	1·27	0·616	0·302
400,000	14·5	5·2	2·26	1·095	0·538
500,000	22·7	8·12	3·53	1·71	0·84
600,000	32·8	11·7	5·08	2·46	1·21
700,000	44·5	15·9	6·92	3·36	1·64
800,000	58·2	20·8	9·04	4·38	2·15
900,000	73·6	26·3	11·42	5·55	2·72
1,000,000	91·0	32·5	14·12	6·85	3·36
1,200,000	..	46·8	20·16	9·85	4·84
1,400,000	..	63·7	27·6	13·4	6·58
1,600,000	..	83·2	36·2	17·5	8·60
1,800,000	..	..	45·7	22·2	10·86
2,000,000	..	..	56·5	27·4	13·42

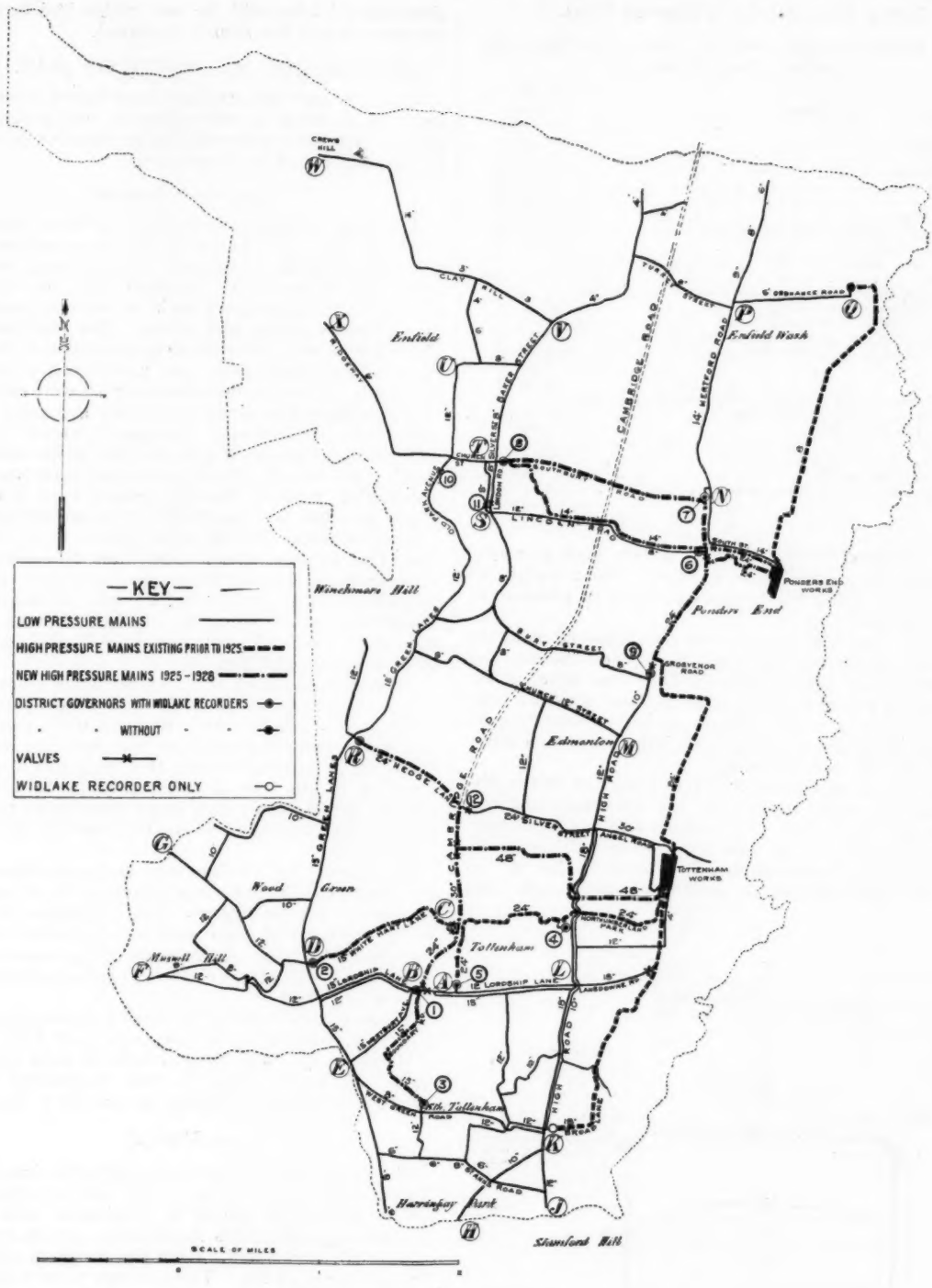


FIG. 13.—TOTTENHAM DISTRICT, 1928.

comparison between the capacities of a 36-in. diameter and a 48-in. diameter main being of particular interest.

The estimated costs of laying the several diameter mains at various depths are given in Table II. These were the piece-work rates, at which the work was later carried out; difficult work being undertaken on a time and material basis in accordance with the Schedule in Table III.

New Boosting Plant.

To feed the new main, two additional Bryan-Donkin boosters were installed, in an extension to the original booster house. These were each capable of passing 1,750,000 c.ft. per hour against a pressure increase of 18 in. of water. To supply these boosters, a 36-in. main was laid from the valve house.

The outlet of the new boosters was connected to a 36-in. pressure-loaded Peebles governor, which is illustrated in fig. 14; the new 48-in. main being supplied through this governor. The governor has worked excellently, being

TABLE II.—*Cost of Mainlaying*, 1924-25.

Diameter of Main in Inches	24	30	36	42	48
Class of Pipe	A.	A.	A.	B.	B.
Cover when laid, in feet	3	3	3	3	4
Cost of pipes per ton	£8 10 0	£8 10 0	£8 5 0	£8 0 0	£7 15 0
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Cost of pipes per yard	2 4 7	3 1 3	3 18 1	5 5 9	6 5 4
Cost of laying per yard	1 11 6	2 8 0	3 5 0	3 16 0	4 4 0
Cartage per yard	0 2 4	0 3 2	0 4 9	0 7 0	0 11 11
Total per yard	£3 18 5	£5 12 5	£7 7 10	£9 8 9	£11 1 3
	s. d.	s. d.	s. d.	s. d.	s. d.
Extra per yard for each 6 in. over stated depth	2 9	3 3	3 6	3 9	4 0

TABLE III.—*Schedule of Daywork Prices.*

[All Rates Include Supervision, Employers' Liability, Third Party Risks, and Use and Repair of Tools.]

	£	s.	d.
Ganger . . (at per hour)	0	2	2
Jointer . . ,, ,,	0	1	8
Timberman ,, ,,	0	1	8
Pipelayer . . ,, ,,	0	1	7½
Shearlegman ,, ,,	0	1	7
Excavator . ,, ,,	0	1	6
Lad . . . ,, ,,	0	0	10
Pump driver ,, ,,	0	1	9
Watchman, including coke for fire (at per shift)	0	9	6
Cartage (at per day)	0	19	0
One lantern, including oil, &c. (at per 24 hours, day and night)	0	0	6
One fence, constituting two trestles and three poles (at per 24 hours, day and night)	0	0	6
Use and waste of timber (at per c.ft.)	0	1	7
Timber left in to engineer's instructions (at per c.ft.)	0	4	9
48-in. lead joints (materials only) (at each)	2	17	0
30 ,, ,, ,, ,, ,,	1	18	6
24 ,, ,, ,, ,, ,,	1	9	0
Hire of petrol-driven floodgate pump (single) (excluding driver) when working (at per day)	0	12	6
Ditto, when not working ,, ,,	*nil*		
Hire of 3-in. or 4-in. floodgate hand-pump (excluding driver) when working (at per day)	0	5	0
Ditto, when not working ,, ,,	*nil*		
Cutting 48-in. diameter pipes (at each)	1	2	6
,, 30 ,, ,, ,, ,,	0	15	0
,, 24 ,, ,, ,, ,,	0	11	6

very easy to load and maintaining a very even pressure. It is loaded by a small pilot governor and a weight of 1·27 oz. on the pilot will give an increase in pressure of 1 in. on the 48-in. main.

The 30-in. Angel Road governor was removed from the old booster house and installed in the new house, and connected to the new boosters. This was done as the new boosters would work at a much lower pressure than the old; and to raise the pressure of the gas required by the Angel Road low-pressure main more than was absolutely necessary was wasteful.

While it was anticipated that improvements in the district pressures would result after the work indicated had been carried out, it was fully realized that full advantage could not be taken of the new trunk main without carrying out additional alterations and extensions, but it was considered advisable not to decide definitely what form these should take until the new mains had been put into commission and the results examined.

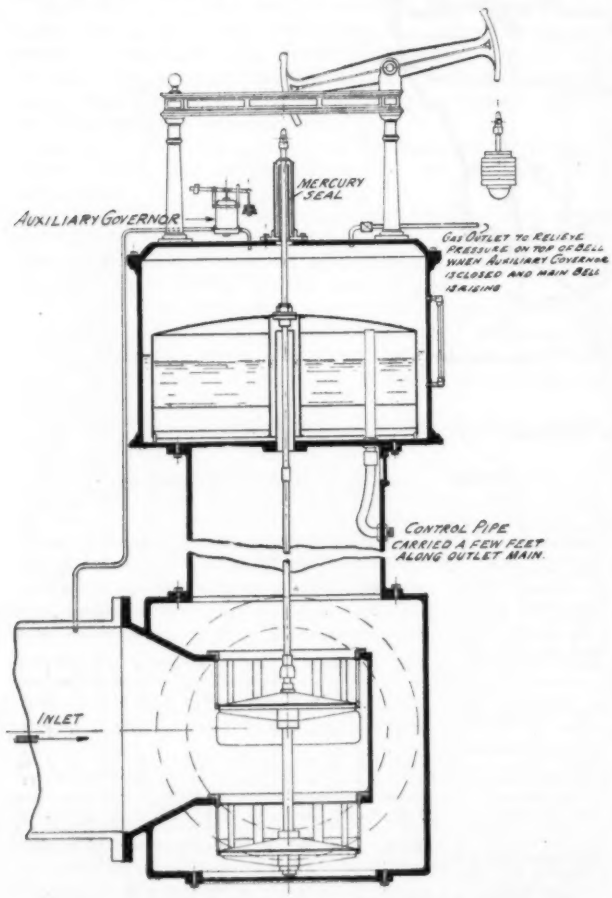

MERCURY SEAL
AUXILIARY GOVERNOR
GAS OUTLET TO RELIEVE PRESSURE ON TOP OF BELL WHEN AUXILIARY GOVERNOR IS CLOSED AND MAIN BELL RAISING
CONTROL PIPE CARRIED A FEW FEET ALONG OUTLET MAIN.
INLET

FIG. 14.—36-IN. STATION GOVERNOR (PEEBLES).

DESCRIPTION OF LAYING OF 48-IN. MAIN.

Very few gas undertakings have found it necessary to lay a 48-in. main on their districts, and a description of some of the parts of the work may therefore be of interest to the members of the Institution.

Survey of Trenches.

After the necessary wayleaves had been obtained, the whole of the route was carefully surveyed and plans to the scale of 44 ft. to one inch were prepared showing the exact line of the route, together with the location and level of all obstructions such as sewers, surface-water drains, water mains, and cables. The existence of these latter works was determined by reference to the records of the Local Authorities and Companies to whom they belonged. In cases where these records were not available, or where there was doubt as to their accuracy, trial holes were sunk. A section of this plan is shown in fig. 15.

A minimum cover of 4 ft. for the 48-in. main was decided upon for all places where the main passed under an existing road or through ground over which a road might possibly be constructed at some future date. In the case of one or two of the wayleaves there was a possibility that at some time a road might be constructed.

Sectional elevations were then prepared, an example of which is illustrated in fig. 15, and the main was positioned in sectional elevation, so that the minimum cover should be preserved, obstacles avoided, and adequate falls to syphons allowed for.

There was a fall of 33 ft. between the point where the 48-in. main entered the New Cambridge Road and the Willoughby Lane Works. Between these two points the fall in the natural groundline was more or less regular; but it is of interest to note that only five syphons were installed in this run of main, 9820 ft. in length. This was no doubt due in very large measure to the complete survey which was made before the work of mainlaying was commenced.

A complete set of drawings and schedule of castings was prepared, the drawings including the necessary bends set to the nearest degree. On completion of the work every casting had been used as originally ordered, and from start to finish of the main-laying operations it was not found necessary to alter the original schedule of castings in any way.

Three gangs were set to work on different sections of the main, starting on 26 Jan., 1925, 17 Feb., 1925, and 9 March, 1925. The entire length of main (including the 30-in. and 24-in. mains in New Cambridge Road) was connected, tested, and ready for gas by 5 Nov., 1925.

Material.

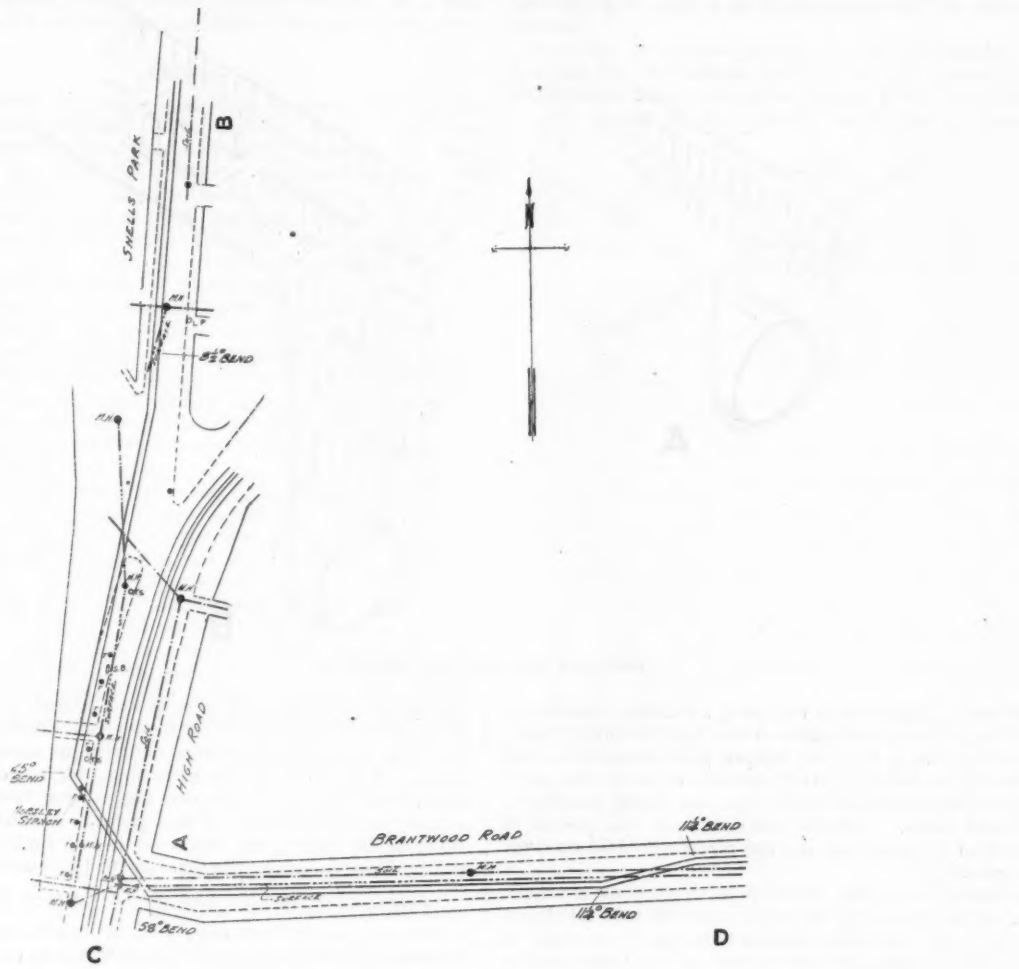
Except for that portion lying under the London & North Eastern Railway, the main was laid in 48-in. cast-iron spigot and socket piping in accordance with the British Engineering Standards Association Specification No. 78, Class "B," uncoated. Each pipe weighed approximately 64 cwt. 2 qr. 24 lbs. The castings were supplied by the Staveley Coal and Iron Company, Ltd., and every pipe and special was examined and tested by our Inspecting Engineer before dispatch from makers' works.

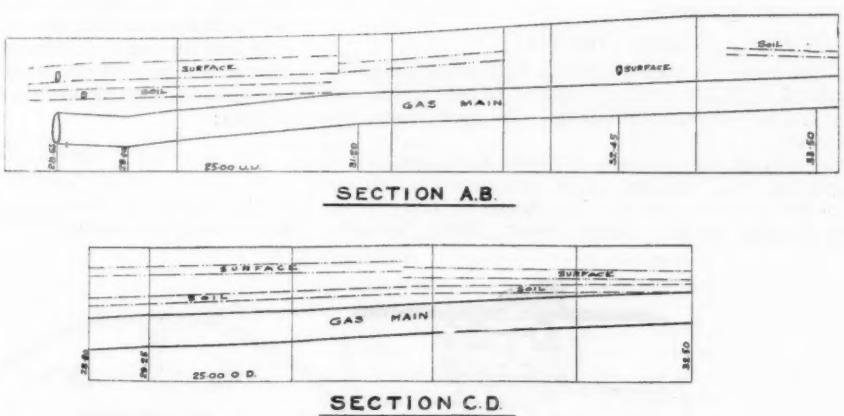
The rate of delivery of the castings to the railway sidings at Willoughby Lane Works was regulated to keep pace with the actual speed of mainlaying, and to provide a little surplus stock.

Trenching and Timbering.

A typical section of the trench required for the 48-in. main when laying at normal depth and in good dry ground is illustrated at "A" in fig. 16. The style of timbering shown may be regarded as uniform, except when laying at a greater depth or when the work was difficult owing to water in the trenches. Under the last-named conditions trenches were timbered in the manner shown at "B" in fig. 16.

The 33-ft. width which had been decided upon for the wayleave was found to be the minimum width necessary for comfortable working. When laying through open country this width was divided equally on either side of the centre line of the trench, one side being used for the





SECTION A.B.

SECTION C.D.

FIG. 15.—SECTION OF SURVEY FOR 48-IN. DIAMETER MAIN.

running of a jubilee track for the carriage of the castings from the nearest roadway, and for the dumping of these castings at the trench side.

A travelling gantry was erected to span the trench, and by means of this the castings were lowered into position ready for jointing-up. The space on the other side of the trench was used for depositing the excavated spoil. The surplus spoil, after the trenches had been filled in and rammed, amounted to about 1½ cub. yards per yard run of main; and this was removed subsequently to the nearest tip.

The subsoil from 3 to 12 ft. below ground-level was generally found to be ballast and sand; but below 12 ft., blue clay was reached, and great care had to be taken with the timbering. In the low-lying ground water was encountered at about 4 ft. depth, and considerable pumping was required. In some cases it was found necessary to pump water into settling tanks, the overflow from which was taken through a 6-in. pipe line roughly laid on the surface of the ground and discharging into the nearest surface-water drain. Several pockets of running sand were met, but the actual trench bottom was good.

In section "*c*," which is near the High Road, Tottenham, the water pumped from the trench was discharged into a storage tank of a local factory. This factory in the ordinary way pumped water from a few feet below the ground surface to supply its needs. This supply failed while the trench pumping was in progress.

Laying under High Road, Tottenham.

The portion of the main under the High Road, Tottenham (section "*d*" in fig. 12), was laid with 9 ft. 9 in. of cover. The traffic on this road is very heavy, and, in-

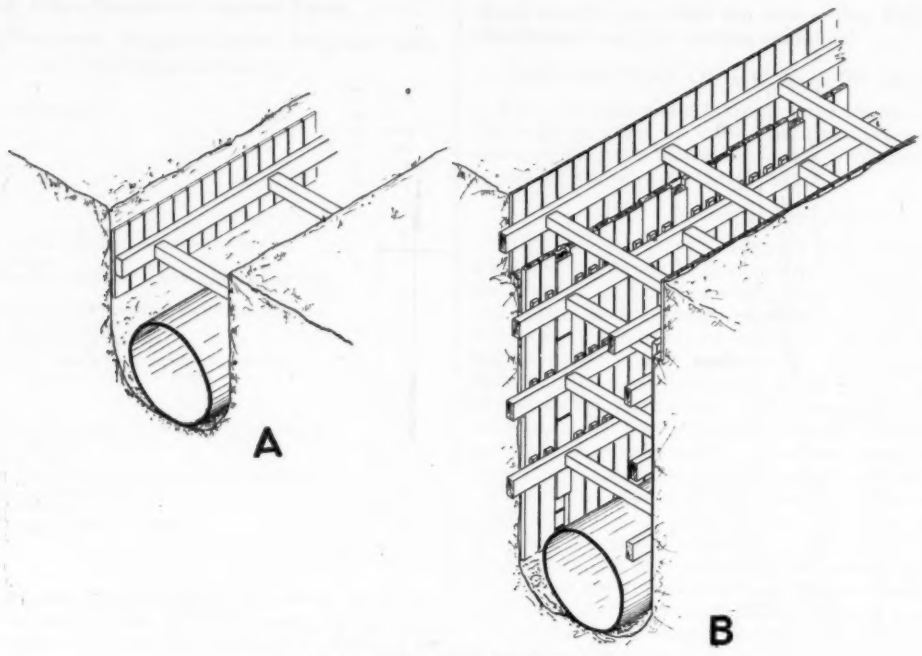


FIG. 16.—TIMBERING OF TRENCHES.

stead of closing a portion of the road, a heading was driven 60 ft. in length from both sides of the road simultaneously. This heading was 7 ft. 6 in. square in cross-section, and was timbered as follows: Half timbers of pitch pine were used for the side trees and head trees, and poling boards for the roof and sides. A 6-in. concrete floor was placed in the bottom of the heading, and the pipes were laid on 6-in. wooden packings.

The heading was then filled in with clay to a height of 12 in. above the main, and weak concrete was filled and rammed into the remaining spaces between the surface of the clay and the underside of the roof; all the timber being left in.

This work was carried out without any interference to the road traffic, and no subsidence of the road track or tram tracks has occurred.

Pumping Trenches.

It was necessary to take particular care when pumping was required in those portions of the trench which ran close to houses or other buildings. In such cases the timber invariably was left in.

At one point at the junction of Snells Park and Grove Road, marked "L" on fig. 12, it was necessary to lay the main for a short distance at a depth of 12 ft. 6 in. in order to pass under a large sewer. Here, unfortunately, an underground stream was found, and also running sand. Five petrol-engine driven floodgate pumps, one 3-in. petrol-engine driven centrifugal pump, and half-a-dozen 4-in. hand pumps were just able to cope with the water; but two days and one night were taken to lay a syphon and two bends at this point. A foundation was obtained by laying the main on heavy timber packings, and by filling in under the bends with bags of dry cement.

Main under London and North Eastern Railway.

The portion of the main 84 ft. in length laid under the London & North Eastern Railway line was constructed in half-inch riveted steel tubing with riveted flanges. The flanges were machined on the faces and were bolted together; the joints being made with red and white lead and lead wire. The Railway Company provided and laid timber baulks under their lines before the trench was opened.

One of the requirements of the Engineer to the Railway Company was that the whole of the main on the Railway Company's property should be surrounded by concrete as follows:

6 in. under the main.
1 ft. 6 in. over the main.
1 ft. 0 in. at each side.

The laying of the portion of the main under the two sets of rails was carried out without interfering in any way

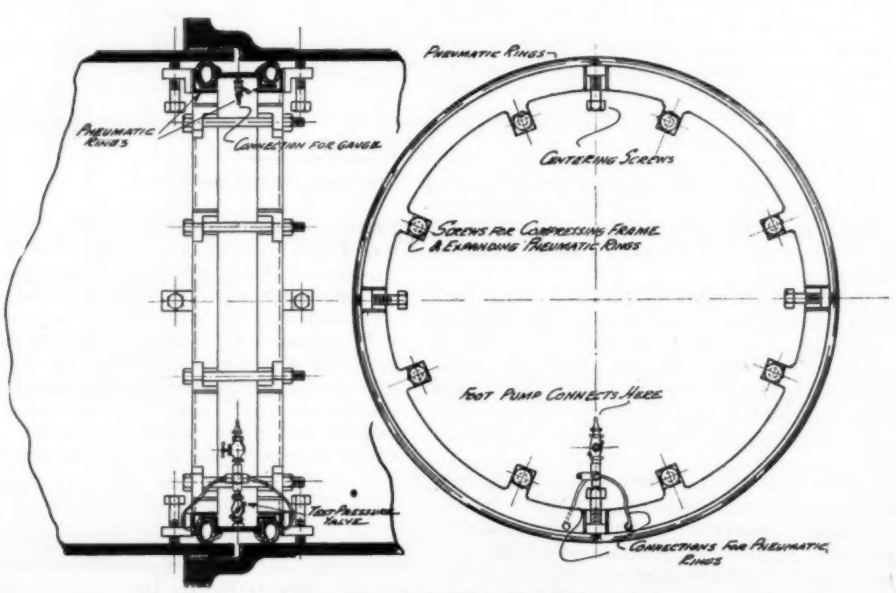


FIG. 7.—LEAD WOOL COMPANY'S TESTING APPARATUS.

with the regular railway traffic, which consisted of a ten-minute service on both up and down lines during the day-time.

Testing.

The quantity of virgin lead used in each joint on the cast-iron main weighed approximately 118 lbs., and each joint was tested separately under an air pressure of 30 lbs. per sq. in. by means of a testing apparatus supplied by the Lead Wool Company. This apparatus is illustrated in fig. 17, and is made of three pieces of steel, two flanged pieces and one centre piece. There are also two specially-constructed tubes, which are inflated and make a joint with the pipe to be tested. The pressure is applied to the space between the tubes by means of either air or a fluid.

In addition to the separate testing of each joint, an air test of 30 lbs. per sq. in. was applied to approximately each half mile of main as laid, and finally a pressure test of 30 lbs. per sq. in. was applied to the completed main. The pressure for these tests was raised by a portable petrol-driven Ingersoll-Rand air-compressor of the type used for general road work.

After charging the main to the desired pressure, it was allowed to stand for two hours; and then pressure readings were taken during the succeeding four hours. The main was passed as being sound if no diminution of pressure occurred during this four-hourly period.

Only one serious leak was discovered during the final test. This was in a split socket about 100 yards to the east of the point where the main passed underneath the railway. The cause of the defect was never quite clearly established. An independent metallurgical analysis made of the iron round about the fracture gave the following results:

			P.Ct.
Total carbon	Graphite	2·444	2·893
	Combined	0·449	
Silicon			2·764
Sulphur			0·063
Phosphorus			1·442
Manganese			0·700

The percentage of phosphorus is rather higher than would be expected in a casting of the weight and size in question, though hardly high enough to have made the pipe brittle. The fracture in the pipe, however, confirmed the importance of the testing of mains before they are gassed. In this case the particular pipe had been examined and tested at the makers' works by an independent Inspecting Engineer. The joint had been tested by the separate joint-testing apparatus. The pipe and the joint had passed both these tests satisfactorily, and it was only on making the whole main test that any leak was discovered.

Laying of 30-in. and 24-in. Mains.

The laying of the 30-in. and 24-in. mains presented no particular difficulties, as these mains were laid under a grass verge at the side of the New Cambridge Road. The actual work of laying was carried out in a highly satisfactory manner by Messrs. William Press & Son, who also performed the work in connection with the modifications for the levelling-up of pressures, which is described in a later part of this paper.

(3) MODIFICATIONS OF SYSTEM FOR THE PURPOSE OF LEVELLING-UP PRESSURES.

The new trunk mains and boosters were of ample capacity and had made it possible to send out from the works all the gas required, even at times of heaviest loads, for some years to come, but, as had been anticipated, it was still not possible to afford satisfactory pressures to consumers on the outlying districts without giving those nearer the works too much pressure. Reference to Table IV. will give some idea of the fluctuations which occurred on Sundays in August, 1925. The positions at which the records were taken may be seen by referring to the plan in fig. 13; the key numbers on the plan corresponding to those in the table.

It was decided that the most satisfactory method of improving this uneven distribution of pressure would be to extend the high-pressure mains farther into the district, and to instal district governors at the points where the low-pressure system was to commence. The standard aimed at was to provide every consumer with an even pressure throughout the 24 hours, this pressure to vary between 6 in. and 4 in. in the mains of the low-pressure system.

The use of district governors was something entirely new on the Tottenham district, which, before the New Cambridge Road was constructed, would not have been by any means an easy district to divide up conveniently

TABLE IV.

No. Point.	Dinner Load.	Aver. Day Pressure.	Lighting Peak.	Extinguishing Peak.	Minimum Pressure.	Maximum Pressure.	Variation. Minimum—Maximum.
A. Waltheof Avenue and Lordship Lane	10·3	4·5	8·8	6·9	3·8	10·3	6·5
B. Roundway and Lordship Lane	8·0	4·6	8·0	6·9	4·1	8·0	3·9
C. Cambridge Road and White Hart Lane	9·5	4·6	8·2	6·9	4·1	9·5	5·4
D. White Hart Lane and High Road, Wood Green	4·1	5·0	7·8	7·2	4·0	7·8	3·7
E. Westbury Avenue and Green Lanes	4·8	4·6	7·8	7·1	4·1	7·8	3·7
F. Muswell Hill Showrooms	3·3	4·5	7·6	8·1	3·3	8·1	4·8
G. Bounds Green Road (district boundary)	3·1	5·0	7·8	7·3	3·1	7·8	4·7
H. 347, Seven Sisters Road (near boundary)	2·0	4·5	8·3	6·8	2·0	8·3	6·3
J. 1, High Road, Stamford Hill (near boundary)	3·8	4·9	7·9	7·0	3·8	7·9	4·1
K. Broad Lane, High Road, Tottenham	6·1	4·5	8·1	6·4	3·5	8·1	4·6
L. 639, High Road, by Lordship Lane, Tottenham	3·4	4·5	8·6	6·7	3·4	8·6	5·2
M. Showrooms, Edmonton	5·1	4·8	7·4	6·8	3·5	7·4	3·9
N. Showrooms, Ponders End, Southbury Road	8·0	5·3	7·7	6·6	3·4	8·0	4·7
P. 120, Enfield Wash (Turkey Street)	4·5	5·0	7·6	6·9	3·5	7·6	4·1
Q. 389, Ordnance Road	2·0	5·0	7·6	6·8	2·0	7·6	5·6
R. Hedge Lane	4·7	5·1	8·0	7·3	4·1	8·0	3·9
S. Lincoln Road, London Road	4·1	5·0	7·7	6·8	3·6	7·7	4·1
T. Church Street, Enfield (showrooms)	3·5	5·0	7·0	6·0	3·5	7·0	3·5
U. Chase Side, Lavender Hill	2·5	5·2	7·7	7·1	2·5	7·7	5·2
V. Baker Street, Clay Hill	2·1	5·0	7·6	7·0	2·1	7·6	5·5
W. Crews Hill	1·1	5·7	7·6	7·6	1·1	7·6	6·5
X. Ridgeway, Hadley Road	2·9	6·0	8·3	7·6	2·9	8·3	5·4

for the purpose of district governing. This road, however, simplified matters considerably, and it was decided generally to make it the main artery for the supply to meet future developments, and to take feeders east and west to the low-pressure mains running north and south in Green Lanes (on the west), which runs through Harringay, Wood Green, Palmers Green, and Winchmore Hill to Enfield Town, and the Hertford Road (on the east), running through Tottenham, Edmonton, and Ponders End to Waltham Cross. Green Lanes and Hertford Road are roughly parallel to the New Cambridge Road.

An examination of the wire map already described pointed to the possibility of converting some of the larger low-pressure mains into high-pressure; and estimates of the cost of doing this showed that it would be much more economical than the laying of additional mains of equal capacity. It would, of course, be necessary to disconnect any services there might be, and to run additional low-pressure mains to pick up the supplies so disconnected. The new low-pressure mains required would, however, only be of small capacity.

The work was considered in stages as follows, and subsequently carried out in these stages, but not necessarily in the order in which they are described. Before carrying out these alterations it was necessary to remove the pressure-wave lamp-controllers. These were replaced by Horstmann clockwork controllers.

Stage I.—West Green, Harringay, Wood Green, and Tottenham.

To improve and level up the pressures in these districts, all low-pressure mains and services were cut off from the 15-in. diameter main in White Hart Lane and the 15-in. main in Boundary Road, which had been connected to the new 24-in. trunk main. A new 6-in. diameter low-pressure main was laid in White Hart Lane, to which the disconnected mains and services were connected.

A 4-in. diameter main was laid in Boundary Road to pick up the disconnected mains and services; this new main

being fed by the other low-pressure mains in the neighbourhood.

District governors were installed at the following points:

1. At the Roundway, Lordship Lane, to supply the 24-in. main in Lordship Lane, and the 15-in. main in Westbury Avenue.
2. At the Green Lanes end of White Hart Lane to supply the 15-in. main in Green Lanes.
3. At the West Green Road end of Langham Road connecting the 12-in. main in Etherley Road, and the 8-in. main in West Green Road.
4. At the Tottenham High Road end of White Hart Lane connecting the 24-in. Northumberland Park main to the 18-in. main in High Road, Tottenham.
5. At the Lordship Lane end of Waltheof Avenue connecting the end of the 24-in. Northumberland Park main to the 24-in. in Lordship Lane.

(The reference numbers denote the positions of these governors in fig. 13.)

It was not possible to make exact estimates of the effect of these alterations, but it was confidently anticipated that if the district governors were set to give 50-tenths or 60-tenths the whole of the districts in question would be adequately served at all times, each consumer having as nearly as might be an even pressure.

No governor was fixed on the Broad Lane end of the 18-in. Lansdowne Road main, as it was considered that the flexibility obtainable by altering the pressure in this main at will from the works would be advantageous.

Stage II.—Enfield District, including Enfield Town, Ponders End, and Hertford Road.

It was decided to convert the 14-in. main in Southbury Road into a high-pressure main, disconnecting all low-pressure supplies, and connecting these to a low-pressure main fed from Hertford Road; this low-pressure main to be 8 in. in diameter reducing to a diameter of 6 in. There was also a 14-in. low-pressure main in Lincoln Road and a 14-in. low-pressure main in Hertford Road, both these mains being fed from the 24-in. main running from the Willoughby Lane Works.

Three district governors were installed as follows:

6. At the east end of Lincoln Road, connecting the 14-in. low-pressure Lincoln Road main to the 24-in.
7. At the east end of Southbury Road, connecting the 24-in. (which was here reduced to 14 in.) to the 14-in. low-pressure Hertford Road main.
8. At the west end of the Southbury Road main, connecting the 14-in. main in Southbury Road, which was to become a high-pressure main, to the low-pressure 14-in. main in Church Street, Enfield.

In addition to the existing supply via Southbury Road, a certain amount of gas was supplied to the Enfield Town district through 8-in. mains in Lincoln Road and London Road, and through a 12-in. main in Old Park Avenue.

Before Stage II. was finally decided upon, calculations were made to see what quantity of gas was being used on the Enfield district, and what the improvement in pressure was likely to be.

These were as follows:

1. 24-in. main from Willoughby Lane Works to Ponders End, a distance of 15,950 ft.
Pressure drop during Sunday cooking load 2·8 in.

$$\text{Quantity} = 3550 \times 2065 \times \sqrt{\frac{2{\cdot}8}{0{\cdot}5 \times 15{,}950}} = 137{,}000 \text{ c.ft. per hour.}$$

2. 14-in. Southbury Road main from Ponders End to Enfield.
Length of main = 8000 ft.
Pressure drop = 4·6 in.

$$\text{Quantity} = 3550 \times 567 \sqrt{\frac{4{\cdot}6}{0{\cdot}5 \times 8000}} = 69{,}000 \text{ c.ft. per hour.}$$

From this amount should be subtracted the quantity used by the consumers whose supplies were connected to the main in Southbury Road, and who were 700 in number.

700 × 13·5 (the average consumption per consumer per hour at cooking peak) = 9450 c.ft. per hour.
Net gas delivered to Enfield Town through Southbury Road main at the rate of 69,000 − 9450 = 59,550 c.ft. per hour.

3. Two 8-in. mains in London Road.
Lengths, 1900 ft. and 2240 ft. respectively.
Pressure drop = 0·6 in. on each main.

$$\text{Quantity (i.)} = 3550 \times 138{\cdot}5 \sqrt{\frac{0{\cdot}6}{0{\cdot}5 \times 1900}} = 12{,}400 \text{ c.ft. per hour.}$$

$$\text{(ii.)} = 3550 \times 138{\cdot}5 \sqrt{\frac{0{\cdot}6}{0{\cdot}5 \times 2240}} = 11{,}400 \quad ,, \quad ,,$$

23,800 c.ft. per hour.

There were 234 consumers connected to these mains *en route*, on whose account 234 × 13·5 = 3159 c.ft. were deducted.

Leaving net quantity delivered 23,800 − 3159 = 20,641 c.ft. per hour.

4. 12-in. Old Park Avenue main.
Length = 7545 ft.
Pressure drop = 0·4 in.

$$\text{Quantity} = 3550 \times 387{\cdot}5 \sqrt{\frac{0{\cdot}4}{0{\cdot}5 \times 7545}} = 14{,}200 \text{ c.ft. per hour.}$$

The total gas delivered to the Enfield Town district as estimated was therefore:

59,550 + 20,641 + 14,200 = at the rate of 94,391 c.ft. per hour.

Say, 90,000 c.ft. per hour.

The quantity delivered to the remaining districts fed by the 24-in. main from Willoughby Lane to Ponders End = 137,000 − 90,000 = 47,000 c.ft. per hour.

In order that the pressure on the Enfield Town district should be under district governor control completely, it was decided to insert valves at the points marked 10 and 11 on fig. 13, so that no gas should reach this district through either the London Road main from Lincoln Road, or through the 12-in. Old Park Avenue main.

All gas would therefore have to pass along the 24-in. main from the Willoughby Lane Works. This 24-in. main was connected to an existing 24-in. main from Ponders End Works, which was converted into a high-pressure main, so that when Ponders End Works was restarted no alteration in the distribution scheme would be necessary.

The following calculations were made to see what the drop in pressure would be in the 24-in. main from Willoughby Lane Works and in the 14-in. Southbury Road main:

Total gas required in whole of Enfield district, all of which would be supplied by 24-in. main = 137,000 + 23,800 + 14,200 = 175,000 c.ft. per hour.

At this rate the pressure drop between Willoughby Lane Works and Ponders End would be

$$\frac{(175{,}000)^2 \times 0{\cdot}5 \times 17{,}640}{(3550)^2 \times (2065)^2} = 5 \text{ in.}$$

The quantity to be supplied by the 14-in. Southbury Road main was 90,000 c.ft. per hour.

Therefore the pressure drop was

$$\frac{(90{,}000)^2 \times 0{\cdot}5 \times 8000}{(3550)^2 \times (567)^2} = 8 \text{ in.}$$

To maintain 6 in. of pressure at the outlet of the governor at the west end of Southbury Road, a pressure of at least 6 in. + 5 in. + 8 in. = 19 in. would be required at the Willoughby Lane Works end of the 24-in. main.

If the consumption were to be increased by 10 p.ct. owing to improved pressures being available for additional consumers, this pressure would be increased from 19 in. to 21·7 in. Such an increase in the peak load consumption was quite possible, and it was therefore decided to modify the Enfield Town supply further by converting the existing 14-in. main in Lincoln Road into a high-pressure main in a manner similar to that already described, and connecting this main to a new 14-in. high-pressure main to be laid from the point where the 14-in. main was reduced to 12 in. (opposite Bertram Road) via Downs Road, Burleigh Road, and Southbury Road; the new main being connected to the existing 14-in. main in Southbury Road at the inlet of the governor (No. 8 in fig. 13).

Stage III.

This stage provided for improving pressures in the Palmers Green and Winchmore Hill districts by continuing the 48-in. high-pressure main in the New Cambridge Road in a northerly direction to the junction of Silver Street, Hedge Lane, and the North Circular Road marked "12" on fig. 13; the existing 24-in. main in Hedge Lane being disconnected from the low-pressure main which supplied it, which in turn was fed by the 30-in. low-pressure Angel Road main. The Hedge Lane main to be then connected to the extended 48-in. high-pressure main and converted into a high-pressure main discharging into the 15-in. low-pressure Green Lanes main through a district governor; all low-pressure supplies being cut off and

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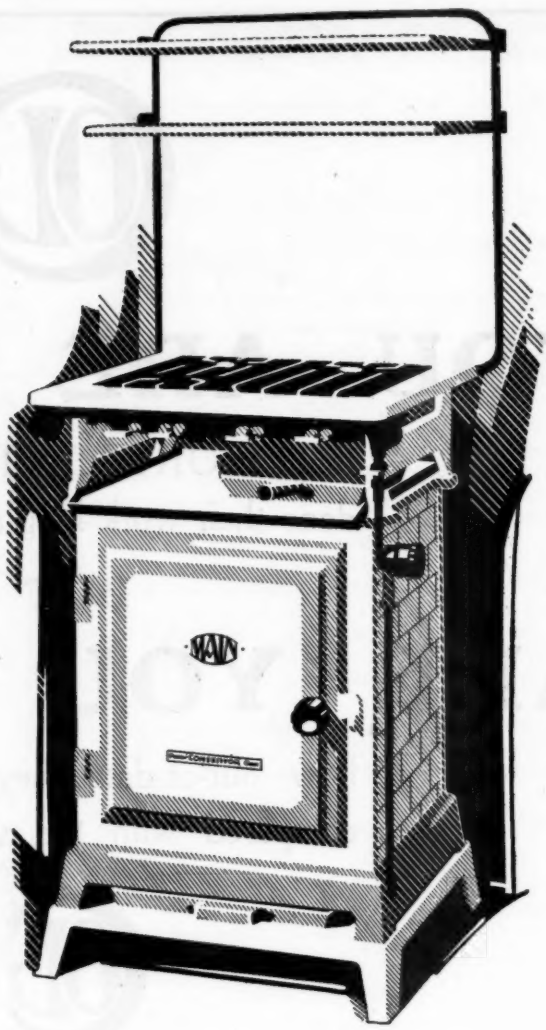

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served in the usual manner by laying an additional low-pressure main from the 15-in. main in Green Lanes.

In addition to improving the pressures in these districts, this stage would also allow of lowering the pressure required in the 30-in. Angel Road main, which was usually 8 in. at the Sunday cooking peak, and nearly that pressure during the winter lighting hours, as all the gas which usually passed along the Hedge Lane main would in future be supplied by the 48-in. main leaving the 30-in. low-pressure main to supply the Edmonton district.

This quantity was estimated to be approximately 160,000 c.ft. per hour, as follows:

Length of main from Willoughby Lane Works to Green Lanes end of Hedge Lane:
4,420 ft. of 30-in. diameter main.
10,095 ft. of 24-in. diameter main.
Pressure drop between these points = 3 in.
Let h_1 = pressure drop on 30 in.
and h_2 = pressure drop on 24 in.

$$\text{Then } 3550 \times 3470 \sqrt{\frac{h_1}{0{\cdot}5 \times 4420}} = 3550 \times 2065 \sqrt{\frac{h_2}{0{\cdot}5 \times 10{,}095}}.$$

$$\therefore \frac{h_1}{h_2} = 0{\cdot}153$$

but $h_1 + h_2 = 3{\cdot}0$ in.

$\therefore 0{\cdot}153h_2 + h_2 = 3{\cdot}0$ in.

$$\therefore h_2 = \frac{3{\cdot}0}{1{\cdot}153} = 2{\cdot}6 \text{ in.}$$

and $h_1 = 0{\cdot}4$ in.

This is only correct if the same quantity of gas is passing along the 30-in. and the 24-in. mains. Actually more passed along the 30-in., so that the drop would be greater—say, 0·6 in.

This leaves the drop on the 24-in. main = 2·4 in.

Therefore the quantity supplied by the 24-in. main in Silver Street and Hedge Lane

$$= 3550 \times 2065 \sqrt{\frac{2{\cdot}4}{0{\cdot}5 \times 10{,}095}} = 160{,}000 \text{ c.ft. per hour.}$$

Assuming that, after connecting the 24-in. Hedge Lane main to the 48-in., 200,000 c.ft. per hour might be required, there would only be a drop in pressure in the Hedge Lane main of 1·72 in. and in the new length of 48-in. main of 0·022 in.

The estimated drop in pressure in Hedge Lane high-pressure main, 4620 ft. in length, was:

$$\text{Drop in pressure} = \frac{(200{,}000)^2}{(3550 \times 2065)^2} \times 0{\cdot}5 \times 4620 = 1{\cdot}72 \text{ in.}$$

Estimated drop in pressure in 1630 ft. of new 48-in. main

$$= \frac{(200{,}000)^2}{(3550 \times 10{,}772)^2} \times 0{\cdot}5 \times 1630 = 0{\cdot}022 \text{ in.}$$

To maintain a pressure of 6 in. on the outlet of the Hedge Lane governor, a minimum of (say) 6 in. + 1·744 in. + (say) 2 in. (to ensure always a surplus pressure on the inlet) = 9·744 (say, 10 in.) would be required at the commencement of the new 48-in. main in Cambridge Road. This would not require any extra pressure on the outlet boosters, as more than 10 in. was already required to serve the Tottenham area.

It was anticipated that the work which has been described, when carried out, would make an enormous improvement in the pressures, and would also provide a most flexible system capable of being easily extended as the district requirements grew. These anticipations have been fully justified; and though there are still one or two areas where the pressure is not all that could be desired, to remedy this is now a simple and comparatively inexpensive matter of low-pressure mainlaying on the outlet side of the district governors.

The charts illustrated in fig. 18 are typical records of the outlet governor pressures.

DISTRICT GOVERNORS.

All the governors used are mercurial governors supplied

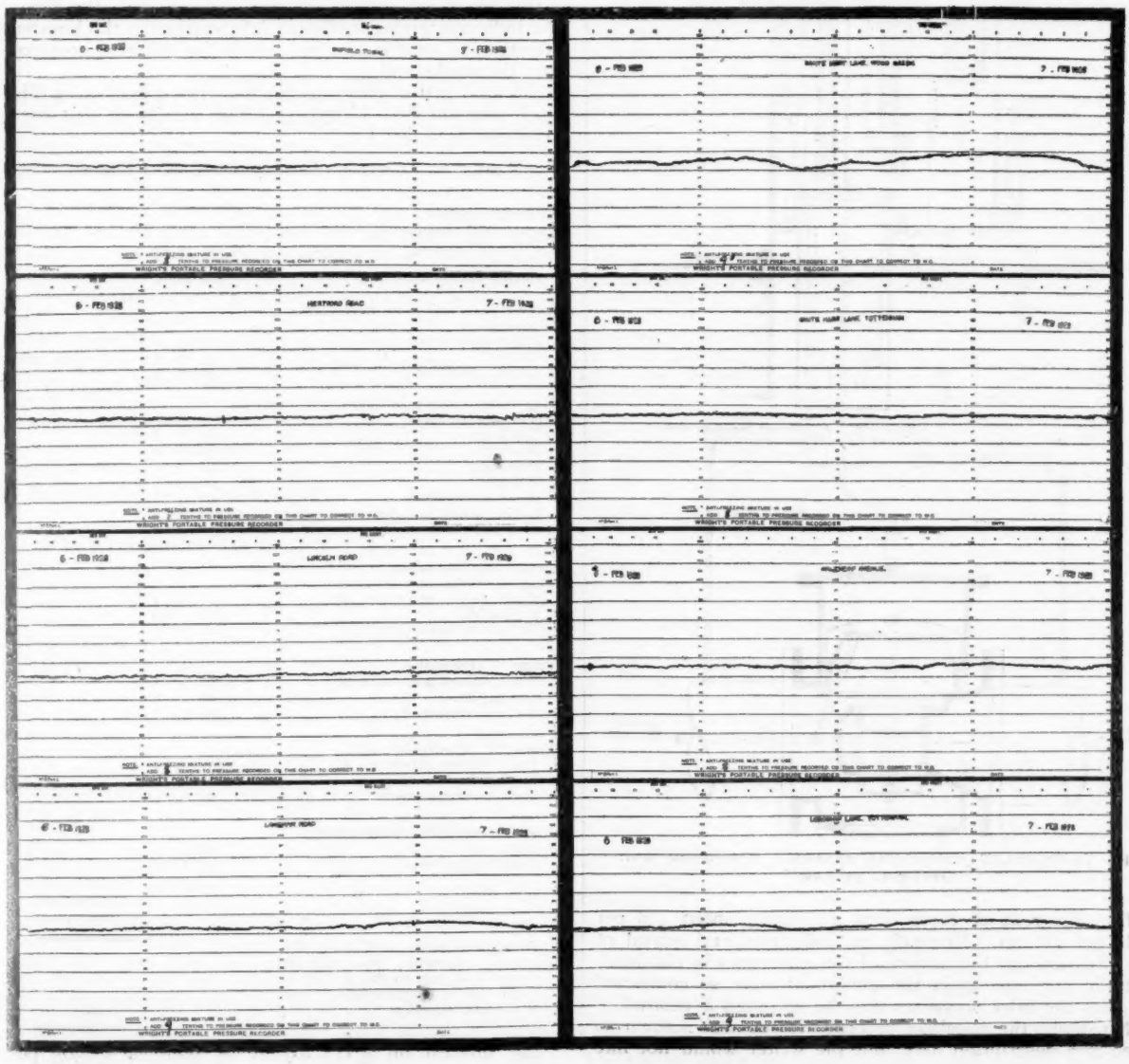

FIG. 18.—OUTLET PRESSURES. DISTRICT GOVERNORS.

by Messrs. Peebles & Co., Ltd., and are of the air-pressure loading type; the pressure loading arrangement being contained in a cast-iron pillar erected at the nearest convenient point. Fig. 19 illustrates a section through one of the governors and control pillars.

The governors have worked admirably, and after the preliminary adjustments, beyond periodical cleaning of the valves and seatings, have required practically no attention whatever.

Great care should be taken in laying the air control pipe to the governors, as it will be realized that, should any leak occur, the governor will close up. The air pipes were laid in brick and concrete ducts filled with pitch, and the governor bell was weighted with lead weights, so that a minimum of approximately 4-in. pressure would be obtained in the event of any mishap to the air pipe or air loading arrangements.

WIDLAKE RECORDERS.

A further precaution was to instal a Widlake apparatus at every governor, the indicators and recorders being erected on a panel in the Booster House at the Willoughby Lane Works. A photograph of this panel appears in fig. 20. The connections between the works and the district were made by lines rented from the General Post

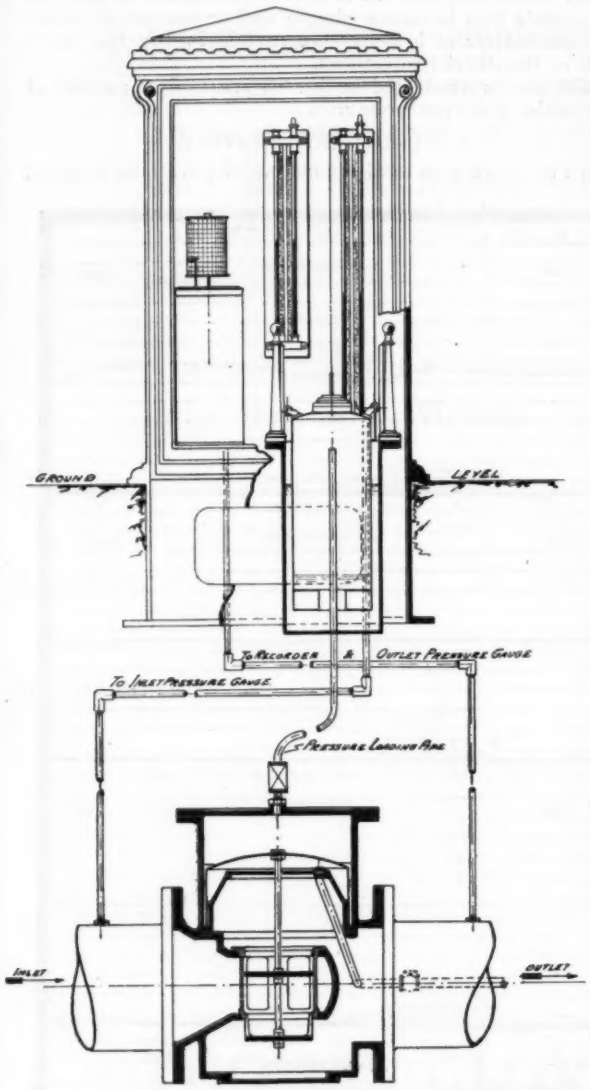

FIG. 19.—PEEBLES MERCURIAL DISTRICT GOVERNOR AND CONTROL PILLAR.

Office, the rent of these lines averaging about £8 per mile per annum. Normally an indication and record of the pressures at the outlets of the governors is obtained, but the instruments at the governors were so connected up that the inlet pressures may be recorded if desired.

No doubt the Widlake recorder is too well known to need any description here, but the writer would not like to let the opportunity pass of expressing his admiration for the excellence of its design and construction, and for the manner in which it functions. Should any district governor fail to act, the booster attendant can see at once by the indicator that something is wrong, and has instructions to telephone immediately to the district inspector in whose district the governor is situated. The recorders provide a permanent record of pressures, which are checked with those taken by ordinary pressure recorders situated in the loading pillars at the governors.

The Widlake indicator has been instrumental in reducing boosting to a minimum. Without such indicators the booster attendant is given definite instructions as to the pressures to be carried on the outlet of each station governor, these pressures being such as to ensure that a sufficient pressure is obtained on the inlet of each district governor to give the required pressure on the outlet (say, an excess of 2 in.). The instructions naturally provide for varying pressures at different hours of each day, and are based on past experience coupled with an examination of the most recent district charts. With the Widlake indicators in operation the booster attendant can so adjust the pressure at the works end of each trunk main as to give the absolute minimum required on the most remote district governor supplied by that main. To enable him to do this satisfactorily, it has been found advisable to use the inlet governor connection to the Widlake apparatus in the case of the last governor on each trunk main. The pressure on the inlet to this governor is maintained at 1 in. above the pressure required on the outlet. The governors have all been set to give 6-in. pressure on the outlets.

All the trunk mains (with the exception of the Broad Lane main) supply more than one district governor. When a trunk main only discharges at one point, as in the case of this main, no district governor is required, the Widlake indicator giving sufficient information to the booster attendant to enable him to control the district pressure from the works end.

The total cost of carrying out the work described in this paper amounted to £113,307. The details of this cost are shown in Table V.

TABLE V.—*Costs of Extensions and Modifications.*

	£ s. d.	£ s. d.
New trunk mains—		
Laying 48 in. main—		
Pipes and specials	22,144 9 10	
Valves	100 10 0	
Laying mains, &c.	29,406 10 10	
		51,651 10 8
Laying 30 in. and 24 in. mains and connections—		
Pipes and specials	6,047 11 0	
Valves	153 12 6	
Laying mains, &c.	6,549 11 5	
		12,750 14 11
New booster house, boosters, and main from valve house—		
Buildings	5,537 7 8	
Boosters	3,134 0 0	
Governor	449 3 0	
Valves	766 12 6	
Pipes and specials	2,167 7 5	
Laying mains and erecting boosters	2,609 18 4	
Steam connections, &c., gauges, &c.	470 1 2	
		15,134 10 1
Pressure levelling scheme—		
Stage I. (Tottenham section)—		
Pipes, valves, governors, &c.	2,408 8 3	
Laying, &c.	5,289 17 10	
Surface reinstatement	622 15 9	
		8,321 1 10
Stage II. (Enfield)—		
Pipes, valves, governors, &c.	4,564 4 8	
Laying, &c.	9,908 11 8	
Surface reinstatement	1,988 10 8	
		16,461 7 0
Stage III. (Winchmore Hill)—		
Pipes, valves, governors, &c.	3,681 13 2	
Laying, &c.	3,800 0 0	
Surface reinstatement	95 0 0	
		7,576 13 2
Installation of Widlake recorders—		
Apparatus	1,252 0 0	
Installation costs	158 13 10	
		1,410 13 10
		£113,306 11 6
In addition to the cost of the Widlake apparatus, the following rental is paid to the G.P.O. for the use and maintenance of the ten lines supplied		£176 18 6

The interest on £113,307 at 6½ p.ct. is £7365 per

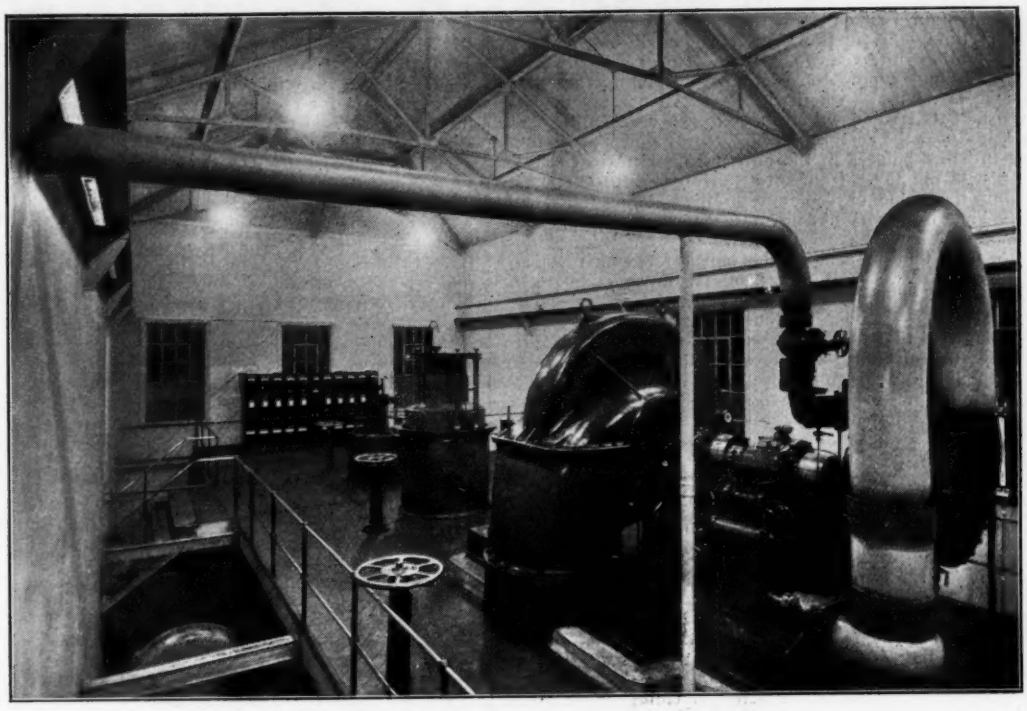

FIG. 20.—NEW BOOSTER HOUSE.

annum, to which should be added the annual rental of £177 paid to the G.P.O. for the use and maintenance of the lines supplied in connection with the Widlake recorders.

In the opinion of the writer it would not be possible for anything like this amount per annum (£7542) to afford to consumers such a degree of satisfaction by any system of inspection and maintenance of appliances as is afforded by ample and even pressure.

There are 96,889 consumers in the Tottenham district. £7542 is equal to 1s. 6½d. per annum per consumer. One shilling and sixpence halfpenny per consumer per annum would not provide much inspection or maintenance for any consumer's apparatus; but for this sum provision has been made to meet future extensions, and, in addition, existing consumers have been provided with what they have a right to expect—namely, adequate and reasonably even pressure at any hour of the day or night.

The writer would like to take this opportunity of thanking his Chairman, Mr. Henry Woodall, M.Inst.C.E., and Directors for giving him permission to present this paper, and also his Chief Assistant, Mr. J. Ledingham, and Chief Draughtsman, Mr. E. O. Rose, for the assistance they have given him in its preparation.

Discussion.

The PRESIDENT: In presenting this paper to you for discussion, I should like to congratulate Mr. Smith on the work he has carried out at Tottenham, and on the very fine spirit of engineering which has governed that work. This paper comes very aptly, I think, following as it does Mr. Lacey's paper. The two seem to fit one into the other. I should like to say that I had the opportunity of seeing the bulk of the work that Mr. Smith has described when I went to Tottenham some months ago to inspect the new boosting plant. We have had similar problems, working on lines something like this. It became necessary to put in a very large booster; and after having a good look round with Mr. Smith, I recommended to my Directors that that type of booster be installed at Grangetown. I hope to have it running by the time you visit the works. There is one problem that we have to bear in mind in connection with distribution work, and that is the problem of meeting the peak loads, the tremendous quantities of gas demanded on Sundays and week-days for cooking, and particularly, as Mr. Shapley has pointed out, the tremendously growing loads from the wash boilers on Mondays. I commend this paper to you; it shows how the work is done, and the difficulties that have been overcome to provide a rapidly growing district with gas. The essence of the paper is to my mind in the summary at the end, where Mr. Smith remarks that he gives even pressure at the cost of 1s. 6½d. per consumer per annum; that is a great thing. I should like to add how much I appreciate the way in which Mr. Smith has prepared the paper for this meeting.

Mr. C. F. BOTLEY (Hastings): The author has set before us in a most interesting manner the way in which he has tackled a problem which is common, I think, in Tottenham. They are always out-growing their clothes there; and he has set before us an ideal of distribution which I think must commend itself. I am not sure that I have a true comprehension of all the details, and therefore I venture to ask Mr. Smith one or two questions. He has given a table showing the result of his preliminary examination of parts of the district, and he says that all the consumers are now receiving gas at an adequate pressure—not necessarily the same pressure, but an adequate pressure—as the result of the work which he has done. I should have liked to see records taken recently at the same points as those at which they were taken in the preliminary examination. Then I should like to know whether that satisfactory line of pressure shown by the outlet governor is really translated to the whole of the area which that governor serves. I am not sure either whether these district governors are isolated in districts, or whether there is any interconnection between one district and another. Is the low-pressure district governor confined to one particular area? Again, I am not familiar with the air loading of the governors and how that is done, and I should be glad if Mr. Smith would refer to that in his reply. Then I notice that in the table of costs of main laying there is no reference to reinstatement, although it is referred to later on in the table relating to the total cost of the work. Mr. Smith has very wisely obtained wayleaves, and has avoided breaking-up public roads. The reinstatement of public roads to-day, especially in view of the new methods of construction, is a very serious matter, which we are having to face daily, and any information that we can obtain on the subject will be very useful. With regard to output, Mr. Robinson, of Harrogate, when discussing Mr. Lacey's paper, stated that his hourly maximum was 10 p.ct. of the maximum daily output. That is an important figure, and if Mr. Smith can tell us what relation his figures of hourly maximum output bear to the maximum daily output, it would be of advantage to us. Finally, I should like to add that I regard this paper as a great contribution to our proceedings.

Mr. RALPH HALKETT (Sheffield): I am very interested in Mr. Smith's paper, because he is dealing with a problem with which many of us have had to deal. We in Sheffield some 8 years ago had great difficulty in maintaining our pressures at certain periods of the day. We were confronted not only with an increased demand for gas for domestic use, but also with a very heavy industrial demand, and in the mornings, particularly in the winter between 7 and 9 o'clock, and again in the evening, just as the domestic lighting load was coming on, we had great difficulty in maintaining our pressures in certain parts of the area, especially in some of the outlying districts, which are in close proximity to the industrial area. After consideration we decided to lay a high-pressure main so that we could boost up from 5 to 10 in. pressure, or anything like that, as required. We found that there was a certain amount of elasticity in that; and, after all, you want a supply which you can control at the various points. We laid a 12-in. high-pressure main to the districts in which we were having trouble, and I am very

pleased to say we have had the greatest success with it. Not only has that main assisted us in the supply of those districts, but a short time ago we purchased two small undertakings some 6 or 7 miles out, and we were able to extend the high-pressure main and supply those small undertakings thereby. We are able to do that without the slightest increase in cost, due to the fact that when we are boosting in order to increase our supply to meet the cooking and industrial load we get sufficient gas into the holders in the outlying districts to carry us over the rest of the day. I am sure that Mr. Smith is right in emphasizing the value of constant quality, composition, and pressure. That is important; no matter how good a pressure we provide, unless we have constant quality and composition we fail to an extent to achieve the object for which we are aiming. I am sure we shall all peruse Mr. Smith's paper with very great interest, and derive great benefit from it.

Mr. G. M. GILL (London): The thing that impresses me about the paper is that the author has put it into such a form that it will be very useful to anyone who is carrying out similar work. I should like to emphasize the value of the trench digging machine that one sees in so many towns in the United States. I do not know whether Mr. Smith has used such a machine; but he does not make any reference to it in the paper. The trench digger is a most impressive machine, and it is extraordinary how much work it will do in a day. I think you can take it that a trench digger will dig about one-fifth or one-quarter of a mile of trench per day in average soil, and there is no doubt that this machine is suitable for use not only in the United States, where wages are high, but also in countries such as ours. One so rarely hears anything of this machine in this country that I thought it worth while to bring it to your notice. Another point in connection with distribution as carried out in the United States which I think is worthy of study is the extent to which many engineers there are using 2-in. pipes as distribution mains. Unless one studies the question closely, I do not think one realizes how much gas can be distributed through 2-in. pipes. It is customary to find in the United States undertakings 70 or 80 p.ct. of whose total mileage of mains consists of 2-in. steel mains. The feeder mains are large; and plenty of gas is put into both ends of these 2-in. pipes, and pipes of that size will supply a surprising quantity of gas. As an illustration—I am giving the figures from memory—a 2-in. main 4000 ft. long, supplied with gas at 5 in. pressure at each end, will distribute 1700 c.ft. of gas per hour with a drop of pressure of 2 in.; that is to say, the pressure at the ends will be 5 in. and in the middle 3 in. That is a case in which the gas is taken off in reasonably even quantities throughout the length. Mr. Smith in his paper refers to a consumption of 13½ c.ft. per consumer during the maximum hour. That figure seems very small; but it is comparable with figures applying to other undertakings. The figure is commonly from 10 to 17 c.ft. per consumer at the maximum hour. A 2-in. pipe will distribute that quantity of gas to something like 100 consumers at the maximum hour; it is simply a question of feeding such pipes in an adequate manner. During the last 12 months I have been concerned with two schemes in British Colonies, in towns of large size having no gas supply, and what impressed me most in working out the figures was the very high capital outlay on mains, and the difficulty of earning interest on that outlay. That is what made me study this method of using 2-in. pipes for a large proportion of the district mains, a method which is commonly employed—I do not say generally employed, but it is employed in many cases—in the United States.

Mr. W. W. TOWNSEND (Colchester): I also should like to congratulate Mr. Smith on his most valuable paper. It is a valuable record of how he has tackled a very great problem in what I consider to be the best way in the circumstances, and it is very appropriate that we should have such a paper at this time, because his problem is one which I think we are always experiencing in a greater or less degree. I am rather sorry that throughout the paper he has had to use the expression "high pressure" to describe a main carrying gas under boosting pressure, because that expression is apt to lead to confusion. I appreciate the difficulty, but I think we have all found that in order to meet the growing demand at the peak of the load it has been necessary to push up the pressure at the works more and more. We found, as Mr. Smith has found, that there are limits to what can be done in that way, and there are generally two alternatives. One is to lay what is really a high-pressure main, often direct from the works, through busy streets; the other is to adopt Mr. Smith's plan, and to use the existing mains through the main streets as feeder mains, cutting off all services and side-street supplies. I would like to draw the attention of members to the large applications of the latter method, which has not been very generally adopted, I think. It will be found frequently that the existing mains through the principal streets of a town will have a much larger carrying capacity if the pressure within them is boosted up only a few inches; but in order to do this it is necessary, as Mr. Smith has found, to cut off all the subsidiary supplies and to lay other mains in the streets for the supply to the consumers. I am very much interested in the way in which Mr. Smith has tackled the problem of reducing the cost of his feeder main, as I prefer to call it—the 48-in. main—by obtaining wayleaves and laying it in private ground. The large saving which can be effected in the cost of a big main by this means is of course obvious, but even in the case of a comparatively small main, with present-day road-making methods, the saving is appreciable. I should like to mention an experience I have had recently in carrying out similar work. We decided to lay a main for over a mile along a public footpath, and we have been advised that we have a perfect statutory right to do so, although the footpath is not repairable by the inhabitants at large, and although the soil is owned by a private person. If Mr. Smith has any experience which will confirm this, it might be of interest to other members, because in many cases wayleaves are paid although the statutory undertakings concerned have power to dispense with them. The only bone I have to pick with Mr. Smith is that in the final part of the paper he seems to make a slighting reference to maintenance. He says it would not be possible, for anything like the amount expended per annum, to afford to consumers such a degree of satisfaction by any system of inspection and maintenance of appliances as is afforded by ample and even pressure. The inference is that you can have one or the other—either a good supply of gas at even pressure, or a system of maintenance. I suggest to Mr. Smith that, now that he is giving a supply of gas at even pressure, he will probably become converted and go in for a complete system of maintenance.

Mr. J. WESLEY WHIMSTER (Bath): I should like to express my thanks to Mr. Smith for his excellent paper. There is just one point in it which I think has a very important bearing on the output of gas undertakings, and that is in connection with his figure of 13½ c.ft. per consumer at the peak load hour. We went into this matter at Bath some time ago. Our peak-load hour consumption is slightly higher, but even so we were very staggered by that figure. If one takes 8 hours a day as being the normal period of consumption, based on the peak-load hour consumption one gets roughly 700 or 800 c.ft. per week, or 40,000 c.ft. per annum; but I take it that Mr. Smith's average consumption per consumer is more than 40,000 c.ft. per annum. That peak-load figure is a very strange one, and one would like to see how it is accounted for. Most of us will say that we have gas cookers in probably 90 p.ct. of the houses in our districts, but it makes one wonder how many of these cookers are really used, if the figure mentioned is really the consumption. In our own case it worked out at about 23 c.ft. per hour, and the annual consumption per consumer, taking the average for the whole of the ordinary sales, is about 60,000, the average consumption per head of population being 15,000 c.ft. The figure of 13½ c.ft. given by Mr. Smith seems to be a very strange one, and I should be glad if he would say whether he has come to any conclusion as to why it is so low.

Mr. W. CLARK JACKSON (Neath): As a rather keen maintenance man, I should like to ask Mr. Smith whether he considers that, however adequate his pressures are now, he can eliminate or reduce the maintenance costs and his service to the consumers. Mr. Townsend thinks that Mr. Smith is only now beginning to give his consumers something like the service that they require. Once you get to even pressures, then you have to see that the apparatus which a consumer has is properly maintained. You may supply gas at even pressure, but then, when all is said and done, there are gadgets which will require fairly regular and constant—and I emphasize the word "constant"—attention. Even in a small undertaking turning out just over 200 million c.ft. a year, such as I control, we employ five fully-trained maintenance people who are continually on the move round our district, with the result that I believe, with the pressures we give, which we try to keep steady, we have now the happiest and most contented consumers of any district I have heard of. We had a little trouble at one time with regard to pressures, but by putting in an intermediary booster and using a holder which we had available—simply filling up that holder during the hours of light consumption and using it during the period of heavy consumption—we were able to balance the pressures without having to increase the size of our mains from the works. If any engineers have a similar trouble, I would remind them to consider whether a small holder at the extreme end of the district would not be sufficient to balance the pressure, and enable them to avoid the very heavy expenditure involved in the laying of new mains direct from the works. In our case, with a consumption of something like 60,000 per hour, it requires only some 8000 c.ft. per hour during the time of peak loads to balance up and equalize the pressure; and a very small holder will do that quite well.

Mr. A. E. BROADBERRY: I should like to take the opportunity of congratulating Mr. Smith publicly, not only on the paper he has read, but also on the excellent results of the work he has carried out. The experience at Tottenham is not exactly unusual in undertakings of that kind; indeed, I think it is typical of a great many, and, therefore, the information will be of use to a great many of us. The only really phenomenal time at Tottenham was, I think, when, with Mr. Terrace, we were revising and re-building the entire works there, and at the same time were encountering increases in demand year by year of anything from 15 to 17 p.ct., and over a period of three years the output had increased by more than 50 p.ct. The natural result of that, of course, was that the mains needed attention as well as the works. Something had to be done to supply this extra quantity of gas. It was then that we first decided to adopt the boosting system, in order temporarily to

relieve the mains; and, due to circumstances which Mr. Smith has described, that boosting system was continued until we had at last reached the economical, if not the physical, limit of boosting. Mr. Smith had to undertake the long delayed revision of the mains; and in doing so he took the opportunity of introducing what has been an ideal to him—the distribution of gas at an equal pressure throughout the 24 hours of the day all over the district. I sincerely congratulate him on the success he has achieved in that way. It is, of course, quite a modern idea, and under modern conditions it is really the ideal to work for.

Mr. STEPHEN LACEY (London) congratulated Mr. Smith on his valuable paper, and intimated that he would contribute to the discussion in writing.

Mr. SMITH, replying to the discussion, said: In the first place I should like to thank everyone who has taken part in the discussion for the generous way in which they have received my paper, and I must thank Mr. Broadberry particularly for the very kind things he has said. After I had written the paper, Mr. Broadberry kindly read through the whole thing to see whether I had gone wrong in any of the historical parts of it, and he gave me many useful hints in connection with it, for which I thank him very much indeed. The President has mentioned the question of the peak load on Mondays, and we are getting now a considerable wash load on Monday mornings. Mr. Botley said that he would like records of the pressures after the modifications were carried out, taken at the same points as those at which they were taken previously. In that connection I ought to say that those pressures recorded on the outlet of the district governors were taken at very nearly the same points as were the pressures recorded previously. Generally it may be taken that the illustration of the outlet governor pressures is typical of the pressures in each of those particular districts, although there are one or two parts of the district where it will still be necessary to lay a few low-pressure mains, but that is now quite an easy and comparatively inexpensive job. Mr. Botley also asked if the district governors are inter-connected in any way. They are only connected on the outlet, and that through the low-pressure system. All the low-pressure system is inter-connected. With regard to Mr. Botley's question as to what I meant by the air loading of the district governors, I think the illustrations will probably make that clear. Instead of putting a weight on the district governor itself, there is an air-sealed vessel over the governor bell which is connected by an air pipe to another bell floating in water, that bell being situated in the control pillar. The weights are put on the air bell instead of actually on the governor, so that pressure may be altered quite easily without getting down to the governor. I agree that I did not include the cost of reinstatement in the table dealing with the cost of main laying, but practically the whole of the reinstatement which was done was of tar-sprayed macadam. The price varied in the different urban districts, but the all-round figure could be taken at 7s. 6d. per yard. Perhaps it would bring the costs in Table II. a little more up-to-date if I say that the labour charges in connection with the work done in 1927 represented a reduction of 5 p.ct. on the 1924-25 charges, and there was also a reduction in the cost of the main. The cost of the 48-in. main purchased in 1927 was £6 7s. per ton, as against £7 15s. per ton in 1924-25, so that the charges now are less than those previously given in the paper. The maximum hourly load on Sunday was approximately 18 p.ct. of the maximum output for that day.

I have not had any actual experience of the trench digging machine which Mr. Gill mentioned as being used in America. With regard to wayleaves in private roads, mentioned by Mr. Townsend, one of the wayleaves was in a private road not repairable at the expense of the public. Section "*c*," referred to in the paper, was laid through a private road serving an estate in course of development. We had no difficulty at all in getting permission to lay the main through that road without payment, the only stipulation being that any good ballast which was surplus should be deposited on a site near by, but I am of opinion that we had no right to lay the main there without permission. In reply to points raised by Mr. Townsend and Mr. Jackson with regard to maintenance, I would not for worlds make any slighting reference to the maintenance and inspection schemes that have been described to us. What I would like to know is the actual cost of such schemes, because I have not been able to get at it yet. We have had a lot of figures given to us from time to time, but when I have gone into them I have always found that the costs are considerably more than what has been stated; and I do feel that before launching out into any grand scheme for the inspection and maintenance of appliances we should get the delivery of gas to the consumer as perfect as possible. I cannot help feeling that if we could supply gas of constant quality and composition and at even pressure, it will be cheaper and easier to carry out an efficient maintenance scheme. The two go together. I feel, too, that the fewer men we have going to the consumers' houses, the better. In one case I know of, after a man has been in to adjust the gas-fires and clean them, there is always a row in the house, and it is said that the gas man has been "messing about again." [Laughter.] I feel that if appliance manufacturers can supply us with fool-proof appliances, and if we can supply the consumers with fool-proof gas, it will be better, but I would not make any slighting reference to any maintenance scheme.

Mr. Whimster referred to average consumption, and suggested that in our case at Tottenham it was probably more than 40,000 c.ft. per consumer per annum. Well, we are not all fortunate enough to live in a district like Bath. Something like 75 p.ct. of our consumers are slot-meter consumers; and their average consumption is about 25,000 c.ft. per annum, about 8000 or 9000 c.ft. of which is for lighting, and the remainder for cooking. The average consumption of the ordinary consumers is round about 40,000 c.ft. I always consider that Mr. Whimster is exceptionally fortunate in regard to the average consumption at Bath, but it is interesting to hear that even in his case, with an average consumption of 60,000 c.ft. per annum, his maximum peak load is only 23 c.ft. per consumer. One thing which has rather impressed us at Tottenham is that, in the case of practically all the additional consumers we have connected up in the last few years, the only means of cooking has been the gas cooker, and yet our Sunday peak load has not gone up. We are coming to the conclusion that now that all these people can walk into a motor car agent's shop and deposit 15s. or £1 and buy a motor car on the hire-purchase system, they picnic on Sundays instead of staying at home and cooking a joint as they did previously.

Mr. Jackson and others mentioned how advantageous it was to have a small holder at the end of a district. We have another scheme in hand at the moment, where we have the advantage of taking over some holders. We are going to lay a small high-pressure main connecting up our existing works with other works, feeding into these holders and then distributing from the holders. I agree that it is an admirable system to be able to adopt.

The PRESIDENT: Before we part there is one thing I should like to call attention to. It seems that the two papers on distribution this morning have appealed to the members, because I have had a letter passed to me by Dr. E. W. Smith asking if I would welcome a suggestion that the Council should set up a small Standing Committee on distribution, to keep the members *au fait* with the subject, and to report fully on the matter. I can only say that I will pass it on to the Council.

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REPORT OF GAS FOR THERAPEUTICAL PURPOSES RESEARCH COMMITTEE.

This Committee consists of Dr. E. W. Smith (Chairman), Sir Henry Gauvain, Messrs. Harold E. Bloor, Chas. F. Botley, Sir Arthur Duckham, Messrs. E. V. Evans, F. W. Goodenough, Dr. H. Hartley, Messrs. Philip G. Moon, W. E. Price, John Wilkinson, and H. James Yates. The Technical Sub-Committee consists of Mr. E. V. Evans, Dr. H. Hartley, and Dr. E. W. Smith.

As no previous comprehensive report has been prepared, it is proposed to review here the development of the work of this Committee from its commencement.

About three years ago, Sir Henry Gauvain lectured in Bristol before the British Commercial Gas Association, and expressed a desire to be able to carry out experimental work, using gas as a source of energy. Sir Arthur Duckham offered to supply a gas plant, if its installation were practicable. On inquiry, it was found that it would be cheaper to pay a high price for gas from the local Gas Company.

At that time it was agreed between Sir Henry Gauvain and Dr. Smith that the first step to be taken should be that of making a thorough inquiry as to the types of radiation that were obtainable from various gas appliances, including gas fires and gas mantles; and Dr. Smith raised the question with Mr. Evans, of the South Metropolitan Gas Company, as to whether they could provide facilities for carrying out the preliminary experimental work in this connection. Mr. Evans promised that if any work of that nature were required, he would arrange facilities for its execution.

Twelve months passed, and the matter was again raised at a meeting that took place between Sir Henry Gauvain, Mrs. Cloudesley Brereton, Mr. Valentine, and Dr. Smith, when the latter proposed that the National Gas Council should be asked to support experimental work by the formation of a Committee working in conjunction with Sir Henry Gauvain. A report was prepared as a result of this meeting, and presented to the National Gas Council by Mr. Goodenough.

The National Gas Council requested the Institution of Gas Engineers to inquire as to the expense of such work, and the possibilities of it being of use to the gas industry.

A representative Committee was appointed, which met Sir Henry Gauvain at Alton, and decided that there was every probability that the work would be of value to the gas industry, but did not then discuss the question of expense. It had previously been reported to the National Gas Council, in the original report, that the total expense that could be expected would be about £400.

After the discussion with Sir Henry Gauvain, during which it was pointed out that the beneficial radiations were not necessarily confined to ultra-violet light, but that other radiations, such as those obtainable from gas mantles and gas fires, might be complementary to the efficaciousness of ultra-violet light. Mr. Evans reported that during the 12 months that had intervened since the matter was first brought to his attention, he had carried out a considerable amount of experimental work, which could be placed at the disposal of the Committee and Sir Henry Gauvain, and that this work included the production of a daylight mantle. As a consequence, the Committee appointed Mr. Evans and Dr. Smith to act as a Sub-Committee in conjunction with Sir Henry Gauvain, to co-ordinate the work that had been carried out by Mr. Evans with the requirements of Sir Henry Gauvain.

Since that time, Sir Henry Gauvain had been in close touch with the Sub-Committee, and with the work that has been carried out by Mr. Evans. An elaborate and very finished equipment has been provided by the South Metropolitan Gas Company for Sir Henry Gauvain's use at Alton.

It has been necessary to bring a special service to Moreland Hall, where the work has been carried out, and to instal a 450 c.ft. per hour meter. This work has been done by the Alton Gas Company on the authority of the Sub-Committee. A representative of Mr. Evans (Mr. Dean Chandler) has visited Alton, and in consultation with Mr. Taylor, of the Alton Gas Company, has advised on the laying of services. The total expenditure approved by the Sub-Committee to date amounts to less than £50.

The details of the research work that has been carried out by Mr. Evans have been presented to the General Committee, but in general it can be said that the aim is to provide, by means of gas, a number of sources of different types of radiation, in order that, by correct blending, Sir Henry Gauvain can experiment on his cases, with a view to determining what effect can be obtained from these different types of radiation or a combination in various proportions of different radiations in conjunction with ultra-violet light produced electrically if necessary. At the same time, it would be possible, with the gas source of radiation, to obtain sufficient heat to make it practicable to carry out such work in well-ventilated rooms.

The three main sources of radiations produced from gas are to be tried, viz. :

1. From the daylight mantle.
2. From the daylight mantles with suitable filters.
3. From gas fire radiants.

These types of equipment are fully illustrated in the photographs prepared by the South Metropolitan Gas Company, accompanying their technical report.

The following is a preliminary report prepared for the Committee by Sir Henry Gauvain.

In accordance with the suggestion of Dr. Smith and Mr. Evans on their visit to Moreland Hall on Oct. 3, 1927, I beg to present a brief statement on the position of the investigation on the therapeutic value of gas now being undertaken at Alton under the auspices and with the assistance of the National Gas Council and the Institution of Gas Engineers.

On the occasion of an address I gave at the British Commercial Gas Association's Congress at Bristol, I first suggested that the time was now ripe for research as to the possible therapeutic value of light derived from coal gas.

The importance of sunlight for health has been long clearly recognized, and it has been abundantly demonstrated that ultra-violet radiation, especially in the region 3000 to 2000 A.U., is of direct therapeutic value in the treatment of surgical tuberculosis, rickets, and many other conditions. A voluminous literature has arisen on this subject, and ultra-violet light derived from electrical sources is now used to a very considerable extent as a routine or accessory treatment for numerous conditions. It is believed by many that the effect of light energy as a means of treatment of disease is very largely due to the ultra-violet radiation, and that visible radiant energy is of comparatively little significance. Very considerable practicable difficulties arise when endeavours are made to utilize light derived from a limited region of the spectrum, and in practice, when ultra-violet light of 3000 to 2000 A.U. wave length is employed, there is always used simultaneously light radiation comprising both visible and infra-red rays. Moreover, while it is admittedly true that for certain physiological effects to be produced ultra-violet light of about 2500 A.U. wave length must be employed, yet there exists both clinical and physiological evidence that effects of great importance are obtained by the combined application of all forms of light energy. Thus on clinical grounds I have no hesitation in stating that in the treatment of surgical tuberculosis by general light baths, sunlight is most effective. The carbon arc light is not as good, and the quartz mercury vapour, or the tungsten, are least valuable. Yet the relative amount of ultra-violet radiation from these sources increases with their diminishing therapeutic efficiency. Leonard Hill has demonstrated that the lethal effect of pure ultra-violet light on paramœcia is approximately halved if they are simultaneously exposed to visible radiant energy.

Sonne has shown that whereas ultra-violet radiation does not penetrate the human skin, visible light, as from the carbon arc, will penetrate the skin and be absorbed in the subcutaneous capillaries, its energy there being converted into heat, and was of opinion that much of the value of the general light bath, whether derived from natural or artificial sources, was due to this property. Sonne is of opinion that this property is of great importance in the local destruction of toxins circulating in the blood stream. It would appear that the penetrative power of visible radiation is largely dependent on its wave length, increasing from the violet to the red end of the spectrum. Thus Murray-Levick claims that the penetrative power of red radiation is of great value in muscular metabolism.

Infra-red radiant energy is so readily absorbed in water that its extended use is limited by the burning effect it produces on the body surface. It is stated that the radiant energy in sunlight is distributed roughly in the proportion of 80 p.ct. infra-red, 19 p.ct. visible radiation, and only 1 p.ct. ultra-violet.

It is a matter of clinical observation that more prolonged exposure may be given to a subject in which radiant energy is thus applied than to a subject where only, or largely, ultra-violet light is used. Moreover, exposure to ultra-violet light of longer wave length is associated with a deposition of melanin pigment in the skin in varying amounts, according to the subject irradiated. This pigment has a protective role, and enables much longer exposure to be safely tolerated by the pigmented than the non-pigmented subject. Many observers claim that pigmentation should therefore be avoided, because the effect of ultra-violet radiation is thereby diminished, but other clinicians of repute, including Rollier, welcome the onset of pigmentation. Skin pigment, other than being protective in nature, has not been shown to be of any therapeutic value; but the fact that no such function has been demonstrated does not necessarily imply that it does not exist. If, therefore, pigment is only of value as protecting the body from ultra-violet light, the excess value of the prolonged exposure which a pigmented subject can tolerate must be ascribed either to light which has a higher penetrative value, *i.e.*, to visible radiant energy, or to exposure of the nude skin to air, which exposure can be tolerated better in the pigmented than in the non-pigmented subject.

Leonard Hill and Argyll Campbell, working at Alton and Hayling Island, have demonstrated conclusively that such exposure to cold air or even better to cold sea water is associated with greater activity of the metabolic process of the body. There is a marked increase in the basal metabolism of the nude exposed patient and such increase is usually demonstrable in the pigmented or non-pigmented subject. It is naturally greater in the winter than in the summer. The average basal metabolism of our nude recumbent patients is 40 p.ct. higher than that of similar patients not exposed and during the sea-bathing basal metabolism may actually be raised 1000 p.ct. above the normal. While in the healthy, well-nourished individual such an increase of internal energy production may be advantageous, in a weakly and cachectic patient it must be limited, as otherwise the subject may be called upon to perform more work than his capacity safely permits. The value of aerotherapy which necessarily is associated with natural sun treatment but which is largely absent in an ordinary light department is strictly limited. Now the improvement derived from well-planned natural sun treatment is greater than can be ascribed to raising of the metabolism as it is not observed in a subject exposed to cold air in a room whether he be pigmented or non-pigmented. It is difficult to explain such improvement by exposure to ultra-violet light alone, as it can be shown clinically that the effects of exposure to artficially produced ultra-violet light associated with the raised metabolic activity due to exposure to cold air, are not equal to exposure to sunlight. *It therefore would appear to be a reasonable inference that exposure to visible radiant energy must be a factor of importance in light treatment. Such a type of radiant energy is readily obtainable by the use of coal gas, and it is an object of this investigation to ascertain to what extent it is of value, if any, and if possible in what way improvement is obtained.*

I am informed that for the production of ultra-violet light coal gas is inferior to electricity, but by the combined use of coal gas and electricity irradiation approximating to sunlight should be obtainable, and the patient can be exposed nude and in comfort in the open air even under the vigorous conditions of an English winter.

The first step in this investigation naturally resolved itself into the design of apparatus suitable for the application of such treatment. This was a matter which naturally should be undertaken by gas experts and one altogether outside my province. In this matter I would record my grateful thanks to The Institution of Gas Engineers and the South Metropolitan Gas Company. The former took the necessary steps to make such an investigation possible, and to the Committee and to Dr. Smith, its technical adviser, I record my profound gratitude. The actual experimental work essential for testing out and constructing the apparatus required was most generously undertaken by Mr. Evans and his assistant, Mr. Chandler, of the South Metropolitan Gas Company. The nature of the apparatus devised will be explained by Mr. Evans, and a first installation has been erected on a balcony at Moreland Hall, where patients, out of doors but under shelter, will receive the treatment.

Moreland Hall was selected for this purpose for the following reasons:

1. It is connected with the Alton gas mains.
2. It is under my immediate control, and the necessary investigation can be undertaken there without being subjected to the interference of a committee, whose permission would have to be obtained, and who might be unsympathetic.
3. Both adult and juvenile patients of both sexes are under treatment.
4. There is a sufficient number of patients available to make the tests of value.
5. The patients are of the educated class, and therefore able to describe their sensations more accurately.

There are three open-air balconies available, two of which have sliding roofs.

The installation at present available is placed on a balcony with a fixed roof. Owing to the fact that the apparatus is fixed, only the occupants of that balcony can receive the treatment, and it is felt that this would so limit the value of the research that installations should be provided on the other balconies, where more patients can be exposed.

It was considered wise, in the first instance, only to equip one balcony, as if early treatment gave little prospect of success the investigations could be abandoned before undue expense was incurred. Systematic treatment has not yet been commenced, because the true value can only be ascertained when the patients selected for treatment are unable to obtain natural sunlight of therapeutic value, *i.e.*, in the winter. Trials have, however, been made, and these have shown clearly that the treatment is practicable, is pleasant, and is eagerly desired by the patients treated. I feel, therefore, justified at this early stage in asking for extensions of the necessary facilities for thoroughly testing the possibilities of the treatment, by having the remaining balconies equipped at once. If it is feasible it would be least expensive if the apparatus to be employed, while similar in principle to that now erected, should be so erected that it may be transferred from bed to bed. This would save much duplication of apparatus. It is proposed to combine with the gas apparatus quartz mercury vapour lamps. I am of opinion that a special type would be required. The ordinary mercury vapour lamp is rich in ultra-violet light of short wave length, and prolonged exposure to that light cannot be tolerated. I have discussed the matter with the British Hanovia Company, and I am informed that a special lamp could be made for producing a larger proportion of ultra-violet radiation of long wave length, and by its use combined with the gas a light would be obtained not unlike sunlight. I think it would be desirable to instal such a lamp to work with the gas lamps.

The Committee met at Alton on Feb. 6, to discuss the present position with Sir Henry Gauvain.

It was agreed that:

1. Nothing of a definite therapeutic value has so far been found by Sir Henry Gauvain from gas heating or lighting with the equipment which has been tested.

2. Heating by means of large cluster inverted burners is convenient and pleasant, and will enable treatment by means of ultra-violet light in the open air to be prosecuted with advantage.
3. Sir Henry Gauvain will continue his work in conjunction with ultra-violet light obtained from electrical sources, but would like a portable heating gas unit installed on the south balcony, and it was agreed that estimates should be prepared for this purpose.

In reply to the query of the National Gas Council as to

1. The expense entailed in this work, and
2. The value of such work,

the Committee is of opinion that no further funds will be required during the next six months.

As regards the results obtained, it is too early to judge, but the fact that one of the leading specialists is enthusiastic in his desire to use gas in every possible way, and that this association is causing him to welcome gas fires for ordinary heating in all rooms is creating a still better atmosphere in the medical profession at a very low cost to the industry.

Should the experiments ultimately prove that radiations obtainable from gas are of definite value in the treatment of patients, a considerable consumption of gas in sanatoria and elsewhere must ensue; but of still greater value to the industry would be the consequent improvement in the already increasingly favourable attitude of the medical profession towards the employment of gas for many purposes in hospitals, nursing homes, surgeries, and consulting rooms, as well as in the homes of their patients.

(Signed) E. W. SMITH, *Chairman.*

Feb. 10, 1928.

Dr. E. W. SMITH (Chairman of the Committee), introducing the Report, said: This is the first Report of a Committee that was formed as the result of a lecture which Sir Henry Gauvain delivered before the British Commercial Gas Association in Bristol about four years ago. It was felt by a number of people who attended the lecture that it would be an advantage if work were carried out to assist Sir Henry Gauvain in the investigations he was hoping to make. The lecture had for its purpose the indication that the increased use of gas would help to reduce the smoke nuisance, and in helping to reduce the smoke nuisance it would assist the work of curing children suffering from phthisis. Sir Henry Gauvain has a light clinic at Alton, in Hampshire, where he has a large number of patients who are being subjected to ultra-violet light with the object of curing them of those diseases which are caused by lack of vitamins and sunlight, and we were all impressed with the absolute necessity of giving every assistance that was possible to such work, if assistance could be given by the gas industry. It was felt by Sir Henry at the time that, inasmuch as the only source of ultra-violet light available, being electrical, was expensive, it was impracticable for that source of light to be applied generally to (say) schools and other places where children congregate in numbers; and consequently, some other source had to be provided. This was the first objective. It was then mentioned to Mr. E. V. Evans, of the South Metropolitan Gas Company, that the first problem to be tackled was to determine the different types of radiation that were available from different kinds of gas lighting and gaseous heating. In other words, it would have been foolish to start on any big scale at the clinic itself with gas lighting or gas heating before we knew something about the radiations that were available; and Mr. Evans, in his quiet way, for a period of over twelve months, carried out a great deal of analytical work in that direction, and gave the Committee that was eventually formed very complete information as to the types of radiation available from gas fires, gas mantles, treated gas mantles—such as daylight mantles—and so on. From that point Sir Henry became enthusiastic, and it was suggested that, as the gas mantle, treated or untreated, appeared to give the type of radiations he would like to experiment with, some equipment be prepared for him with which to experiment on some of his patients. Owing to the generosity and broad-mindedness of the South Metropolitan Gas Company, a complete finished equipment was supplied and installed in one room at Alton. It has been installed for some time, and has enabled Sir Henry to gauge in a broad way what the possibilities are. You will appreciate that a man of Sir Henry's standing, or, indeed, any scientific man concerned with that particular problem, cannot give an opinion within a period of months or even years, because it is necessary to have a very large number of patients under different conditions, and to get an average of the results obtainable—and the results obtainable from a few patients are very misleading in many cases. These problems are perplexing, and the position now is that Sir Henry is satisfied that the problem is not merely one of applying ultra-violet light for short or longer periods, localized or applied generally, to patients, depending on their particular complaints, but that there are other factors which enter into the treatment, and which until a short time ago were undreamt of. I am not a specialist in this matter, and am not posing as one who knows anything about the subject. I am merely reflecting what I have heard at Committee meetings. I think it will be clear to you if I say that sunlight as such has the greatest curative value, and that one type of radiation extracted from sunlight, or reproduced like sunlight, such as ultra-violet light itself, is of very little value. It can be overdone. As an instance of what I mean, I might recall an explanation given by Sir Henry to the Committee not long ago, in answer to a question as to why people living in the tropics were not perfectly healthy, and why they frequently suffered from the very diseases we are trying to assist in curing. He said that a native in the tropics very quickly has sunburn, or a pigment on his skin, and this pigment has the effect of preventing the ultra-violet light from penetrating the epidermis. Thus, the natives or the inhabitants of the tropics do not obtain as much of the ultra-violet light as one would expect.

Of the other factors that are thought to be of value, first it is found that the receptivity of the patient is considerably increased in proportion to the amount of fresh air passing over the skin which is receiving the ultra-violet light. In this country, where there is sunlight during only limited periods, the fresh air is often too fresh, and it is necessary that the patient's skin should be heated. It is found that if the skin can be stimulated by other radiations, such as the heat radiations or the infra-red, then the skin is more receptive again to the small quantity of ultra-violet light which is necessary for curative purposes. A great deal of work is being carried out by Sir Henry, and I think by Dr. Hartley and others, in connection with that type of radiation other than ultra-violet, and which may be of assistance as an adjunct to ultra-violet light. I am particularly interested in that, because when the work of the Gas Heating Research Committee was first carried out, in about 1910 or 1911, experiments were conducted in the colouring of the radiants of gas fires in order to determine, not the health-giving rays of the gas fire, but rather the effect on the efficiency of the gas fire. I am not talking for the Therapeutical Committee when I say that in my belief, if it were possible to obtain radiant heat at a lower initial temperature than that at which we get it now, but as efficiently, it would be more acceptable domestically, and it would be healthier. I do not suggest for one minute that the present gas fire is not healthy, but I have stated before that in my view the present gas fire is to heating what the searchlight is to lighting. What we want is more diffused heating, or, in other words, lower-grade radiations in greater quantities, less intensive and less concentrated. I believe this has a direct bearing on the subject of the use of heat and light and ultra-violet light for curative purposes. Sir Henry is synthesizing, or trying to synthesize, light for curative purposes. He is taking ultra-violet, heat, and infra-red rays, and other rays, and, by suitably proportioning them, he is trying to get down to the effects obtainable in curative work. The next step is that he has asked the Committee to supply him with portable equipment. At the present time there is one room at Alton in which the equipment has been installed. He has asked now that there should be one small unit, sufficient for one patient, and that it should be movable from one bay to another, and capable of transportation if necessary from one room to another. There is no doubt that the Committee will supply him with that equipment, and that he will be able to get on with the next stage of his work. He reports that the patients ask for the particular conditions that we can give, that they like it, and that it does assist—perhaps psychologically more than in any other way—the curative work.

There is another point which is of extreme interest to the gas industry, because I think our main interest in this is not from the philanthropic point of view, but rather from the point of view of demonstrating to the general public not only that gas is not unhealthy, but that it can be, and is, if used properly, a means of assisting health; and if we can get the medical authorities and others to be not just sympathetic, but more enthusiastic in the use of gas for many other purposes medically than they have been in the past, the wrong impressions that have been created will, in a very helpful way, and in a very proper way, be neutralized. Sir Henry tells me he is frequently asked to advise in connection with problems which might conceivably incorporate gaseous heating or gaseous lighting; and I can tell you that he has a very open mind on the whole subject and is a very good friend to the gas industry, while maintaining his complete independence.

Finally, I should like to help you to visualize what the difficulties are in the use of gas. If you were to give the ultra-violet light which is necessary for curative purposes solely from a daylight mantle, there would be a great deal too much heat developed and radiated on to the patient, and therefore, in my view, it can be taken as definite that gas cannot fill the whole bill. The ultra-violet light that is necessary is too much associated with heat radiation; and, therefore, it is proposed, and it must be faced, if finance is to be found, that gas shall be used in future in conjunction with electricity as the main source of ultra-violet light as distinct from the other radiations which may be found eventually to be equally as efficacious for curative purposes. The Committee is a small and enthusiastic one, and,

though we do not meet very frequently, I think we ought to feel very much obligated to Sir Henry for the work he has done, and particularly to the South Metropolitan Gas Company for all that they have done to assist the Committee.

Discussion.

The PRESIDENT: This is a matter in which I have taken a great deal of interest. In the first place, I have proved what Dr. Smith has said, that for therapeutic purposes you can have too much heat; and I will refer to a case in point. I know a lady who has suffered terribly, and still suffers, with neuritis in the arms and shoulders. When I had read the rough copy of Sir Henry Gauvain's report, I was able to tell her what to do to relieve the pain, and she told me afterwards that by exposing her arms and shoulders to the radiations from the gas fire in her room she obtained tremendous relief in ten minutes. I went into the question and found that she was using a fire which had a cokette mat, as the result of which the amount of radiant heat coming from the fire was materially less than that coming from an open radiant fire. From that time I have thought a good deal about this matter, and the lady I referred to tells me that every time she is troubled with neuritis she exposes her arms and shoulders to the gas fire, at a certain distance, and obtains relief. She has said, "Thank God for this gas fire." I really believe we are on the verge of some very big discoveries in this direction, and I mentioned this in my Presidential Address. It was written when I was convalescent in a hotel at Porthcawl. A doctor there told me about ultra-violet light, and said he had had special glass put into his nursery. By the time I had finished with him he had found that the gas industry had a very deep interest in this matter, and was surprised when I was able to inform him that the ultra-violet rays were only 1 p.ct., and the red rays were about 90 p.ct. Again, I had the privilege of visiting the Radiation Research Laboratory, and was conducted over it by Dr. Hartley, and I saw the researches that were being made into the red rays and the ultra-violet rays. I saw the graphs showing the penetrations into the skin, as measured electrically, and was tremendously impressed. Some hours were spent with Dr. Hartley, and I learned a good deal more than I ever knew before about the different rays. One remark of Dr. Smith which impressed me was that relating to the small amount of ultra-violet rays which causes pigmentation of the skin and prevents penetration. The doctors want rays that will clear the toxic influences from the blood, and in order to do this the rays must have a skin penetration of $\frac{3}{8}$ in. So far as I understand it, ultra-violet rays will not do that, but the red rays have a penetration of at least $\frac{3}{8}$ in.—that is, I believe, down into the cuticles of the skin. This is a matter of immense interest to the industry, because, after all, the industry is out to serve the consumer; and if we can by co-operation with the medical profession produce fires which are even more healthy than they are to-day, and if we can make them curative and able to take the place of sunlight, I do not think we shall have lived in vain. I should like to place on record our great appreciation, as an Institution, of the splendid work of Sir Henry Gauvain, and of the Committee over which Dr. Smith presides. The work is most important, and I do not think this is fully realized in the Institution. There is a great deal more behind it than has come to the front.

Mr. SAMUEL GLOVER (St. Helens): We are again sitting at the feet of Gamaliel; we accept the Report with very hearty thanks, and look forward with very great interest to a further report. We desire to send from this meeting an expression of our hearty thanks and appreciation to those concerned with this work, and to those who have stimulated it; and I propose a resolution to that effect.

Prof. J. W. COBB (Leeds): I shall be very pleased to second this, for I was about to speak in much the same terms as those used by Mr. Glover. I think the meeting owes a great deal to Dr. Smith, too, for his elaboration and explanation of the report. He makes it clear that we are dealing with a very complicated matter, and that we are now in the very early stages of an investigation which might occupy, quite naturally, a long time in producing tangible results. I think that what he has said completely justifies the very restrained expressions used in the report.

The PRESIDENT: There is one point I want to raise, and that is that the Institution has been called upon for a small amount of money for this Research Committee. I wanted to emphasize also the wonderful work which has been done by the South Metropolitan Gas Company, and meant to have mentioned Dr. Carpenter and Mr. Evans. I understand that they have spent a very large sum of money on the investigation in the last twelve months.

Mr. GLOVER: When I expressed thanks to those who had stimulated this work, I was thinking of the work of the South Metropolitan Gas Company; and I think the meeting would desire that a message of thanks be sent to Dr. Carpenter.

A resolution of thanks to Dr. Carpenter, Sir Henry Gauvain, and the Committee was accorded with acclamation.

EDUCATION SCHEME.

Report by the Chairman, Mr. F. W. GOODENOUGH, C.B.E.

The past year has been notable for three steps in the development of the Gas Education Scheme, each of which is calculated to have marked advantageous results in the future.

DISTRICT EDUCATION COMMITTEES.

The first is the setting up of District Gas Education Committees. This process of devolution, which formed part of the revision of the Gas Education Scheme adopted by the Institution at its Annual Meeting in 1927, has already resulted in quickened interest all over the country. It has led to a detailed consideration of the education problem in all its phases by many who had previously taken only a general interest in the subject; and, by enlisting local effort in the adoption and working of the scheme in each district, has stimulated that direct and persistent effort without which any such scheme is bound to fail.

An important piece of incidental work just completed by the District Education Committee is the revision and compilation for each district of a new panel of examiners in practical gas fitting.

A list of the Committees formed, with the names of the Chairman and Secretary of each, will be found in Appendix A.

QUALIFICATION FOR MEMBERSHIP OF INSTITUTION.

The second important development is the acceptance by the Institution of the principle that possession of the Higher Grade Certificate and the Diploma shall go a long way towards securing the holder admission to membership of the Institution in the future. This will give great encouragement to the juniors in the industry to undertake the severe courses of study necessary to success.

COURSES FOR TEACHERS.

The third step forward taken in the past year (as foreshadowed in our last report) was the holding for the first time by the Board of Education of a week's course of training for teachers and prospective teachers under the scheme, which they greatly appreciated and, we believe, benefited from.

Part-time technical instruction depends to a great extent on non-professional teachers whose chief qualification is practical experience in and knowledge of the industry in which they are engaged during the day, and whose teaching work, naturally, often suffers from lack of teaching skill. The provision for such teachers of a certain amount of training in the art of teaching, with particular reference to the special problems of part-time study, is therefore obviously desirable, and is certain to improve the standard of technical education in every industry in connection with which such courses for teachers are provided. The Committee consequently cordially welcomed the offer of such a course for teachers in gas subjects made last year by the Board of Education, and repeated this year; and take this opportunity of asking members to give every facility and encouragement to teachers, actual and potential, employed by their undertakings to attend the week's course of training, which it is hoped will become a regular part of the Gas Education Scheme.

ENTRANTS FOR EXAMINATION.

The number of candidates entering for the various examinations of the Institution shows an increase on those

of last year, not so large as had been hoped, but still enough to show steady growth. The following is a comparison of the year's figures with those of last year :—

Gas Engineering.

—	Ordinary Grade.		Higher Grade.		Diploma.	
	1927.	1928.	19 7.	1928.	1927.	1928.
Internal candidates .	48	36	18	36	..	..
External candidates .	40	35	25	25	8	18
	88	71	43	61	8	18

Gas Supply.

—	Ordinary Grade.		Higher Grade.		Diploma.	
	1927.	1928.	1927.	1928.	1927.	1928.
Internal candidates .	42	48	9	15	..	..
External candidates .	18	35	7	3	..	3
	60	83	16	18	..	3

Total number of candidates in all grades :—

—	1927.	1928.	Increase.
			P.Ct.
Gas engineering	139	150	8
Gas supply	76	104	37
	215	254	18

A consideration of the preceding table gives grounds for both satisfaction and disappointment. It is eminently satisfactory that no less than eighteen students have qualified to sit for examination for the Diploma in Gas Engineering as compared with eight last year. For the first time, too, we have entries for the examination for the Diploma in Gas Supply. In both cases we undoubtedly see part of the fruition of the work of the five years during which the Education Scheme has been in operation.

On the other hand it is rather disappointing to have to draw attention again to the small numbers entered for the Higher Grade in Gas Supply, and also to the fact that out of the thirty technical institutes and Colleges having approved courses only fifteen had students entering for the Institution Examinations this year. (A full list of the centres having approved courses in gas subjects is given in Appendix B.)

PROGRESS IN RELATION TO THE NEEDS OF THE INDUSTRY.

It is, however, impossible to appraise the whole position correctly without taking into consideration the other two sections of the Education Scheme—those in which the examinations are conducted by the City and Guilds of London Institute, namely, the Grouped Courses in Gas-Works Practice and Gas Supply Practice, and the Gas Fitting Courses. The entries for examination in these subjects this year are as follows :

Grouped Course in Gas-Works Practice	12	
,, ,, in Gas Supply Practice	70	
		— 82
Gas Fitting, Grade I.	309	
,, ,, ,, II.	131	
,, ,, Final	43	
		—483
Total	565	

Relating these figures to those given above for the major courses, we are enabled to judge of the position of technical education and training in the industry as a whole. This, while showing progress, still falls far short of the necessities of the industry; as may be judged by the facts that, on the average, there was only one candidate sitting for examination, under any of the various courses, per statutory gas undertaking in the British Isles, and out of the total of 819 candidates, 60 p.ct. sat for Gas Fitting only. (A list of centres having approved Minor Grouped and Gas Fitting Courses is given in Appendix C.)

SUBJECTS FOR THESES.

The subjects for their theses chosen by the candidates for the Diploma in Gas Engineering and Gas Supply range over a very wide field and are as follows :—

Gas Engineering:

1. The Formation and Elimination of Tar Emulsions.
2. Recovery of Coke from Ashes in Gas-Works.
3. The Complete Recovery of Waste Heat on Gas-Works, including Steam.
4. The Effect of Carbonizing Temperature on Coke and Gas.
5. The Determination of Condenser Capacity.
6. A Study in Carbonization.
7. Some Aspects of the Working of Internal Producers with suggestions for Improved Efficiency.
8. Some Notes on Wet and Dry Purification with particular regard to Temperature Control.
9. Waste Heat Recovery in Gas-Works.
10. Exhausting and Governing Gas from Retorts.
11. The Importance of Simultaneous Observations of Waste Gas Temperatures, CO Content, and Chimney Draught in the Control of Combustion.
12. Purification of Coal Gas.
13. Condensation and Ammonia Extract.
14. The Probable Advantages to be derived from Mechanically Agitating Coal in the upper portion of a vertical retort.
15. Condensation and Ammonia Extraction.

Gas Supply:

16. Gas Fire Flues.
17. Some Aspects of the Motions of Fluids in Pipes.
18. Differential Charges for Gas and their Effect on Sales.

AN APPEAL TO MEMBERS.

In conclusion, the Committee feel that, although from the nature of the industry it is inevitable that there must be some ebb and flow in the numbers presenting themselves for examinations from year to year, the flow is not yet as great as it should be if the best interests of the industry are to be served. They therefore again ask for the fullest possible co-operation of the members of the Institution in pressing the necessity and advantages of the Education Scheme, not only upon the juniors of their staffs, but upon the administrative heads of their undertakings who can do so much to encourage and facilitate the attendance at classes, &c., of their employees, both staff and non-staff; so that the education and training of those who in the future will be called to positions of responsibility in the industry, and of all those engaged in its service to the public, may be fully equal to what the stress of modern conditions demands.

F. W. GOODENOUGH,
Chairman.

May 21, 1928.

APPENDIX A.

LIST OF DISTRICT COMMITTEES WITH NAME OF CHAIRMAN AND SECRETARY.

District.	Chairman.	Secretary.
Eastern ...	... F. Prentice	... E. F. Keable, Engineer and Manager, Gas-Works, Southtown, Great Yarmouth.
Irish	... J. D. Smith	... G. Airth, Gas-Works, Dundalk.
Lancashire ...	... S. Tagg, J.P.	... J. Alsop, Gas-Works, Bolton.
Midland ...	... F. C. Briggs	... H. R. Hems, Gas Department, Council House, Birmingham.
North of England	... C. Dru Drury	... H. Lees, J.P., Gas Office, Hexham.
Scottish ...	... Dr. T. Gray	... David Fulton, Gas-Works, Helensburgh.
Southern (S.E.)	... L. Trewby	... W. T. Kenshole, Gas-Works, Lea Bridge, Leyton, E. 10
Southern (S.W.)	... R. Robertson	... S. Hole, Gas-Works, Bath.
Wales ...	... H. D. Madden	... O. Thomas, Gas-Works, Pentre, Rhondda.
Yorkshire ...	... J. Bridge	... C. H. Chester, Gas-Works, Wakefield.

APPENDIX B.

LIST OF CENTRES HAVING APPROVED MAJOR COURSES IN GAS SUBJECTS.

O.E. = Ordinary Grade Gas Engineering.
H.E. = Higher Grade Gas Engineering.
O.S. = Ordinary Grade Gas Supply.
H.S. = Higher Grade Gas Supply.

Bath Technical College	O.E.	H.E.	O.S.	—
Barnsley Technical College	O.E.	—	—	—
Birmingham Technical College	O.E.	H.E.	O.S.	H.S.
Blackburn Technical College	O.E.	H.E.	—	—
Bournemouth Municipal College ...	O.E.	—	—	—
Bradford Technical College	O.E.	H.E.	O.S.	H.S.
Bristol Merchant Venturers' Technical College	O.E.	—	O.S.	—
Burnley Technical College	O.E.	—	—	—
Cardiff Technical College	O.E.	H.E.	O.S.	H.S
Coventry Technical College	O.E.*	—	—	—
Derby Technical College	O.E.	H.E.	—	—
Dewsbury Technical College	O.E.	—	—	—
Dundee Technical College	O.E.	H.E.	O.S.	H.S.
Edinburgh Heriot-Watt College ...	O.E.	H.E.	O.S.	H.S.
Glasgow Royal Technical College ...	O.E.	H.E.	O.S.	H.S.
Halifax Technical College	O.E.	—	—	—
Hull Technical College	O.E.	—	O.S.	—
Huddersfield Technical College	O.E.	H.E.	O.S.	H.S.
Leeds Technical College	O.E.	H.E.	O.S.	—
London—				
East Ham Technical College	O.E.	—	O.S.	—
Polytechnic, Regent Street	O.E.	H.E.	—	—
,, Tottenham	—	—	O.S.	—
Sir John Cass, Technical Institute ...	O.E.	—	—	—
Westminster Technical Institute ...	O.E.	—	O.S.	H.S.
Liverpool Technical School	O.E.	H.E.	—	—
Luton Evening Institute	O.E.	—	O.S.†	—
Manchester College of Technology ...	O.E.	H.E.	O.S.	—
Plymouth Technical College	O.E.	—	—	—
Salford Royal Technical College ...	O.E.	H.E.	O.S.	H.S.
Southampton University College ...	O.E.	—	O.S.	—
Stoke-on-Trent Technical College ...	O.E.	—	—	—
Wigan Technical College...	O.E.	—	—	—
Wolverhampton Technical College ...	O.E.	—	O.S.	—

* First two years of course. † Ancillary subjects only.

APPENDIX C.

LIST OF CENTRES HAVING APPROVED MINOR GROUPED COURSES IN GAS-WORKS PRACTICE, GAS SUPPLY PRACTICE, AND APPROVED COURSES IN GAS FITTING.

GAS-WORKS PRACTICE.

Bath Municipal Technical College.

GAS SUPPLY PRACTICE.

Bath Municipal Technical College.
Birmingham Central Technical College.
Cardiff Technical College.
London :—
Acton and Chiswick Polytechnic.
Borough Polytechnic.
East Ham Technical College.
Hackney Institute.
Tottenham Polytechnic.
Westminster Technical Institute.
Tunbridge Wells Technical Institute.

GAS FITTING.

Bournemouth Municipal College.
Dudley Technical College.
Eastbourne Technical Evening School.
Exeter Gas Light and Coke Company.
Leamington Spa Technical School.
Leicester College of Technology.
London :—
Croydon Central Polytechnic.
East Ham Technical College.
Finchley Evening Institute.
Hackney Institute.
Tottenham Polytechnic.
Watson House, Nine Elms Lane.
Westminster Technical Institute.
Ramsgate Technical Institute.
Tunbridge Wells Technical Institute.
Wolverhampton Technical College.
West Bromwich (Kenrick) Technical College.
Weston-super-Mare School of Science and Art.

Since the above Report was prepared, the following candidates have obtained Diplomas in Gas Engineering in the examinations of 1928 :—John Grayston (Hinckley), 1st with distinction; Roy Summerson (Luton), 1st with distinction; Frank C. Sylvester (West Bromwich), 1st; James L. Hyslop (Belfast), 2nd; W. I. Ineson (Bradford), 2nd; Harold B. Kendrick (Carlisle), 2nd; and Egbert Harold Winch (Cambridge), 2nd.

The PRESIDENT : I have a telegram from Mr. F. W. Goodenough, the Chairman of the Committee, who was to have presented the report. It is addressed to Mr. Terrace, and is as follows :

> Greatly regret coincidence of Sales Managers' session of Advertising Convention, Birmingham, prevents me presenting Education Report, but was not consulted as to place in programme. Greatly obliged if you will present Report of Committee, of which you so enthusiastic and valued member. Progress is maintained. Alterations proving great improvement. Hope for steady advance if all members actively co-operate.

Mr. JOHN TERRACE introduced the report, and formally moved its adoption.

Mr. SAMUEL GLOVER (St. Helens) : I second most heartily the adoption of the report, and would commend the work of this Committee to the attention of the members with the utmost confidence. Having been a member of the Committee from its inception, and having been an examiner under the City and Guilds of London Institute for six years previous to this, I have watched its work with very great interest and care.

The PRESIDENT : I also should like to commend it to you. I have done a little work in connection with the Examining Board, and have been Chairman for the last five years; but this is my last year of office. In submitting my resignation to the Advisory Committee, I felt that one individual should not hold the same office for so many years, and that new blood should come in. It is true that the men coming on to-day have a better technical training than we had in our time, though we had the best that was then available; and if we are going to elevate the younger people to a higher plane, we must move away and give place to examiners who have had the advantage of the later training. With that in my mind, and with the knowledge that I have done five years' work on the Examining Board, I felt that someone else ought to have the honour of occupying the chair. At the same time, the work has been a very great pleasure to me; I do not want anyone to think that I have regarded it as hard work, because I have not. I have a great interest in the Junior Associations, and, equally with our Senior Vice-President, Mr. Terrace, I have tried to do my best for them; but I think the Institution this year should allow me to retire, and another to take my place.

The report was adopted.

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SOME APPLICATIONS OF CHEMISTRY IN GAS-MAKING.

By H. HOLLINGS, M.Sc., Chief Gas Chemist to the Gas Light and Coke Company.

The Transactions of this Institution have been enriched for many years past by the publication of frequent reports upon the scientific investigation of particular problems which have arisen in connection with the manufacture of gas. The programme of this meeting alone provides evidence that there is within the industry a vigorous prosecution of chemical research. Reference to the Technical Journals will also show that there has been no failure to develop methods of chemical analysis and physical test which are required by the industry.

The object of this paper is neither to discuss any particular problem of chemical research, nor to describe any new analytical process, but rather to describe attempts which have been made in several directions to apply the result of purely chemical work in the art of gas-making, and to employ the deductive methods of the research worker in the interpretation of daily observations.

The Carbonization of Coal.

When attempting to obtain increased thermal yields of straight coal gas, it is often difficult, in the absence of facilities for making quantitative tests on a large scale, to correlate cause and effect. An increased yield of gas may result, for example, from more complete carbonization of the coal or from the elimination of mechanical losses by leakage or from secondary decomposition of liquid products. The latter phenomenon is of particular interest to the chemist, because, while a moderate degree of cracking is profitable, an excess is harmful. Unfortunately our fundamental knowledge of the mechanism of the reactions involved is very limited, and in our study of working results we are often handicapped further by the impossibility of obtaining quantitative measurements of coal and its products relative to a particular retort house and a particular type of coal. Valuable guidance may be obtained, however, from purely chemical analyses of the products of carbonization, provided that these are correlated with other data available.

Table 1.

—	1.	2.	3.	4.
Section of retorts, in.	24 by 18	24 by 18	22 by 16	22 by 16
Age of retorts, days	1130	810	840	360
Charge of coal, lbs. per c.ft. of retort space	28·5	35·2	38·4	28·6
Temperature of combustion chamber, °C.	1320	1370	1370	1260
Time of carbonization, average in hours	13·6	13·6	10·1	13·0
Free carbon in tar, p.ct. dry basis	20·7	11·4	10·9	15·0
Inert-free gas—				
Calorific value, B.Th.U. per c.ft.	628	620	614	653
P.ct. hydrogen	54·04	55·75	56.42	51·90
,, methane	34·61	33·33	32·60	37·45
,, carbon monoxide	7·75	7·35	7·48	6·80
,, hydrocarbons (C_nH_m)	3·59	3·57	3·50	3·85

In Table 1 some analyses of gas and tar produced in some of the horizontal retort houses of the Gas Light and Coke Company are tabulated, together with particulars relative to the retorts, and carbonizing conditions. They are examples only, and, though each is based upon the average of six months' working, it must not be supposed that they provide a complete solution of the many complex scientific and economic problems of carbonization. While much more definite information might be deduced, if we knew with accuracy the quantity of coal supplied to each retort house, consideration of these results may suggest methods by which we may seek to obtain improved results with existing apparatus.

The particulars of the gas are expressed upon an inert-free basis. This practice is adopted for several different purposes in this paper, as it is found to facilitate the analysis and comparison of results. Considering the results as a whole, it is worthy of note that, when expressed upon this basis, the calorific values of gas made under differing conditions from the same type of coal vary within relatively narrow limits. A knowledge of these calorific values obtained in horizontal retort practice without steaming is a useful guide in the analysis of working results of steamed vertical retorts which is described later.

One of the most important conditions of coal carbonization in horizontal retorts is that the largest possible charge of coal should be placed within the retort, compatible with the facilities for heating the coal and with the necessity for preserving a free path of travel of gas to the ascension pipes. In certain existing plants erected to satisfy conditions very different from those which prevail to-day, limitations are imposed by the design of the coal-charging machines or by the design of the retort-heating arrangements, but it is our general experience that low working-costs depend in no small measure upon the maintenance of a high rate of output, which to a large extent depends upon a heavy charge of coal. Comparison of the results shown in Cols. 2 and 3 with those shown in Cols. 1 and 4 of Table 1 will show the influence of the heavy coal charge upon the free carbon content of the tar, which is quoted here primarily as a generally recognized index of tar quality. It is shown in Table 2 that, when the quality of tar is improved in this way, the yield is also enhanced, and it is suggested that the free carbon content furnishes an index of carbonizing conditions.

It will be noted that higher combustion-chamber temperatures are employed to carbonize the heavier charges of coal, but it is significant that these higher temperatures have less influence upon the degradation of the tar than has the extension of the time of heating tar vapours produced by a falling-off in the weight of coal charge per unit volume of retort space.

The sectional dimensions and the average ages of the retorts are given in Table 1, together with the average periods of carbonization. The influence of these factors upon tar quality has been discussed upon a previous occasion (J.S.C.I., 1926, **45**, 406T) in some detail. It is our general experience that it is easier to obtain a good-quality tar from retorts which are free from the defects associated with their old age, and also from small retorts. It is necessary to carbonize a deeper mass of coal in a deeper retort for a longer time than is necessary for the complete carbonization of the coal in a smaller retort. During this extra period the volatile products from the centre of the large coal charge come into contact with coke, and pass through a free space in contact with the retort wall, at a temperature higher than that during the earlier part of the carbonizing process. Furthermore, in the case of the large coal charge, a greater proportion of the primary tar is evolved at a time when the gas velocity in the retort is relatively low; and hence it is subjected to the high-temperature treatment for a longer time. Thus at least a portion of the volatile matter from the larger coal charge is subjected to more drastic thermal decomposition. In so far as such increased decomposition takes place in contact with coke, it is not to be anticipated that the tar will contain the whole of the resultant free carbon, since the coke will remove some of the solid decomposition residues by filtration; but there must be some increased thermal decomposition in the free space, due to the higher temperature of the free space, and to the lower gas-velocity in the free space towards the end of the longer carbonizing period in the larger retort.

At one of our works provided with horizontal retorts, definite efforts have been made during the past four years to increase the charges of coal fed into each retort. In Table 2, the effect of this upon the average yearly working

Table 2.

—	1924.	1925.	1926.	1927.
Free carbon in tar, p.ct. dry basis	19·4	16·7	14·3	13·0
Yield of tar per ton of coal, galls.	8·3	8·7	8·8	9·4
Yield of gas, therms per ton	70·7	71·4	70·2	71·6
Carbonizing wages, pence per therm	0·413	0·393	0·392	0·379

results is shown. There has been a marked improvement in the quality of tar, accompanied by a substantial increase

in the yield of tar, and it will be seen that this has been obtained without any sacrifice of gas yield. It is also noteworthy that there has been a simultaneous decrease in working costs, and this is exemplified by the charge in respect of carbonizing wages, which shows a progressive decrease notwithstanding a slight increase in wages rates during the period. It will be observed that the rate of progress was arrested during 1926 owing to the coal strike

At this particular works, it would appear that we are now rapidly reaching the limit of what may be achieved by merely increasing the charge of coal, and that, in order to secure any further economies in working, it will be necessary in the immediate future to study other factors. Some of the lines on which this study is being pursued are indicated in this paper.

Reference has been made already to the calorific values of gas in Table 1. The gas analyses are given to show the combined influence of lower temperatures. and of the cracking of tar vapours upon the hydrocarbon, including the methane, content of the gas. This influence is seen in Cols. 1 and 4 compared with Cols. 2 and 3, Table 1.

It will be appreciated that the major difficulty confronting us in any purely chemical interpretation of results is to decide what are the conditions which will give the most profitable degree of decomposition of the primary products of carbonization without involving an unprofitable decomposition of other hydrocarbon constituents. This, however, is a subject which still requires attention in the research laboratory.

Analyses of Light Spirit.

In the above tabulation of gas analyses, just the amount of detail which is normally available in technical practice has been given. If it were possible to distinguish in all cases between the several unsaturated hydrocarbons present and also between the several paraffins which are normally expressed as equivalents of methane and hydrogen, it is probable that many more valuable and interesting deductions might be made. It is unfortunate that the difficulties inherent in precise gas analysis prevent any such distinction in general work. One method which appears worthy of further study is to separate the olefines as their bromine derivatives. This has been described recently by the Fuel Research Board (Tech. Paper No. 19).

Another method is to make a detailed examination of the spirit which may be extracted from the gas by means of oil or active charcoal. By such extraction some of the hydrocarbons present in the gas are concentrated in a form amenable to chemical analysis. In Table 3 a comparison is made between the analyses of spirits obtained by stripping the gas from light and heavy coal charges respectively.

Table 3.

Weight of coal charge, lbs. per c.ft of retort space	28·6	..	37·0
Combustion chamber temperature	1320° C.	..	1370° C.
Spirit per c.ft. of gas, c.c.	0·790	..	0·838
Analysis of spirit—			
Loss on acid washing	4·20	..	4·40
Carbon bisulphide	1·29	..	0·79
Paraffins	2·10	..	4·39
Benzene	77·75	..	68·63
Toluene	10·44	..	14·43
Xylene (to 135° C.)	1·34	..	2·32
Residue above 135° C.	1·92	..	3·44
Loss during analysis	0·96	..	1·60
	100·00	..	100·00

It will be seen that with the heavier charge of coal, and consequent decreased free space within the retort, there is again evidence of reduced thermal decomposition in the results shown for the paraffins and the aromatic hydrocarbons of higher boiling point. It will be noted that with the light charge there was a lower combustion chamber temperature, and it is probable that the average temperature within the retorts having the light charge of coal was at least no higher than the average temperature within the retorts having the heavy charge of coal. For this reason this difference in degree of thermal decomposition may be ascribed to the difference between times of heating, rather than to any temperature difference.

It is well known that high temperatures within the retort favour the formation of carbon bisulphide, and it is of interest to note the evidence contained in the above analyses that light charges also favour the formation of carbon bisulphide.

The distillation curves of the two spirits after acid washing are given in figs. 1 and 2.

Distillation Curve of Acid Washed Benzol from light charge of coal in Horizontal Retorts.

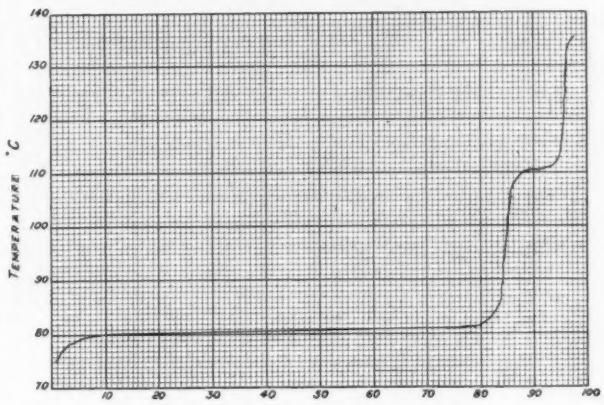

Fig. 1.

Distillation Curve of Acid Washed Benzol from heavy charge of coal in Horizontal Retorts.

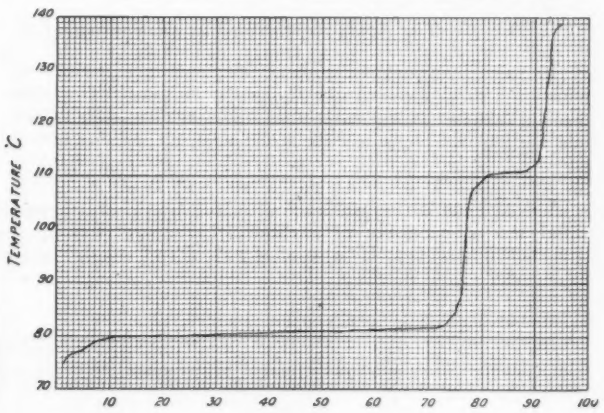

Fig. 2.

As an illustration of the very different conditions which prevail in continuously operated vertical retorts, an analysis of spirit extracted from vertical retort gas is given in Table 4.

Table 4.

Loss on acid washing	20·84
Carbon bisulphide	0·43
Paraffins (to 150° C.)	20·05
Benzene	29·56
Toluene	9·50
Xylene	5·10
Residue above 150° C.	13·21
Loss during analysis	1·31
	100·00

Fig. 3 shows the distillation curve of this spirit after acid washing, and by comparison with figs. 1 and 2 shows very clearly the different nature of the spirit.

The unusually high proportion of unsaturated hydrocarbons removed by acid-washing of paraffins and of higher aromatic hydrocarbons is evidence of much less drastic thermal decomposition within the vertical retort.

The whole question of the composition of this spirit extractable from vertical retort gas is under investigation, as it is of interest from many points of view; and it is hoped the result of this investigation may be published, in greater detail, on some other occasion. From a consideration of the above analysis and of others which have been published already (H. G. Colman, J.S.C.I., 1919, **38**, 67T), it will be realized that caution should be exercised in considering any proposal for the recovery of motor spirit from vertical retort gas.

Though the higher proportions of phenols resulting from the use of vertical retorts are widely known, the

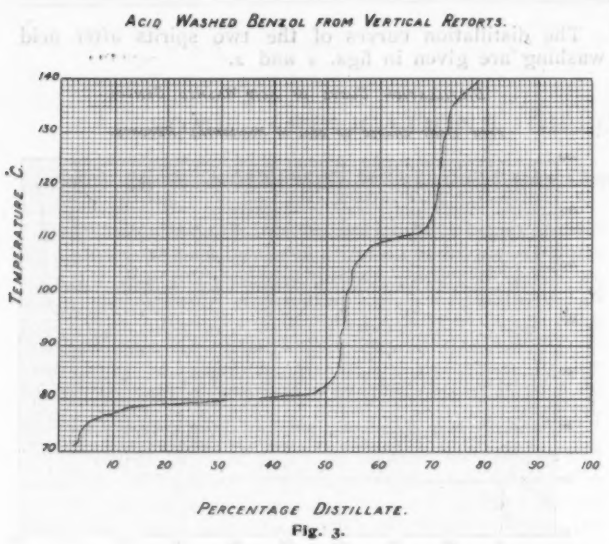

Fig. 3.

phenol contents of tar and liquor derived from the same coal carbonized in horizontal and vertical retorts respectively, given in Table 5, may be quoted to illustrate the possibility of using such results as indices of carbonizing conditions.

TABLE 5.—*Tar Acids Represented as an Equivalent of* C_6H_5OH.

—	Horizontal Retorts.	Vertical Retorts.
P.ct. in tar	0·78	1·60
,, in liquor	0·056	0·310

Valuable as is the guidance provided by purely chemical analyses of products of carbonization correlated in the manner illustrated, it is realized that the results would be of much greater value if the quantities of each product of carbonization under different conditions, expressed in absolute units per ton of coal, could be determined, but there are many difficulties in arranging for such investigations in works having more than one retort house. Because of these difficulties, we have recently erected an experimental carbonizing plant in connection with a new research laboratory. This plant consists of a train of condensers, washers, and purifiers leading to a common inlet to a pair of gas meters. The meters are geared together in such manner that a definite small proportion of the gas is passed through one meter into an independent holder. The remaining gas is passed through the other meter into one of the works mains. A special governor maintains an equality of pressure in the two meter outlets, and thereby secures accuracy of measurement. The sample of gas collected in the holder is submitted to detailed examination.

To this plant there may be conducted either the whole of the gas made in one or two horizontal retorts of full working size contained in an independent setting, and provided with a separate coal charging machine and weighing machine, or the whole of the gas made in one vertical retort contained in an adjacent setting of modern design and provided with an independent coal hopper and weighing machine. When more results have been obtained by means of this plant, such data as are given above may be supplemented by more absolute data.

It does not appear possible, however, that all the variations of carbonizing practice can ever be investigated in this quantitative manner on isolated units of plant. However desirable the possession of an experimental plant of this type may be, such methods of chemical study as it is sought to exemplify in this paper will always be essential.

ANALYSES OF WASTE GASES.

The analyses of waste gases leaving the combustion chambers of retort settings are commonly used only for the purpose of control of the secondary air supply, the object being to obtain efficient combustion of the producer gas with a minimum excess of air. Such an elementary application of chemical control is of primary importance in regard to fuel economy; but still further information may be deduced from these analyses, provided that the gas has been carefully sampled and accurately analyzed. If the analyses of the products of combustion of any mixture of producer gas and water gas are expressed upon an air-free basis, they should contain 20·9 p.ct. of carbon dioxide, provided that the fuel (coke) from which the gas was made was free from hydrogen. If it is found that the products of combustion contain carbon monoxide, the necessary adjustment in the calculation presents no real difficulty, and need not be discussed here. In practice, it is found that the air-free products of combustion from retort settings usually contain less than 20·9 p.ct. of carbon dioxide; the deficiency frequently being greater than can be accounted for by assuming the presence of hydrogen in any form in the coke fuel used in the generators.

Such deficiencies of carbon dioxide as have been noted in certain instances can only be explained by assuming that the waste gases contain products of combustion of crude coal gas which, on an air-free basis, contain only about 12 p.ct. of carbon dioxide. Evidence in support of such a supposition, that in certain circumstances there is a leakage of coal gas into the combustion chambers, is afforded by fig. 4. The graph plotted shows the carbon dioxide concentration of the air-free waste gases from one of our horizontal retort houses. It is considered significant that this concentration falls immediately after the charging of retorts with fresh coal. The periods during which retorts were charged are indicated by the heavy horizontal lines above the graph. In certain instances, where waste-heat boilers are installed, it has been noted that at corresponding times there is an increase in the heat content of the waste gases entering the boiler sufficient to cause a temporary rise in the boiler steam pressure.

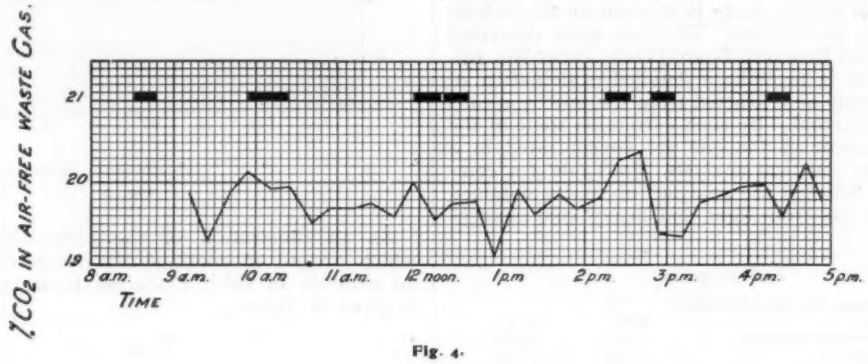

Fig. 4.

If the average composition of the air-free gases is known with sufficient accuracy, a calculation may be made of the approximate thermal equivalent of the coal gas leakage—*e.g.*, if it is assumed that the consumption of fuel in the generator is equivalent to 12 lbs. of carbon gasified per 100 lbs. of coal, then the minimum quantity of hydrogen leakage, inclusive of the hydrogen content of hydrocarbons, may be expressed as therms per ton of coal, as indicated in Table 6 for the several concentrations of carbon dioxide in air-free waste gases shown.

In so far as the coal gas contains oxygen combined with carbon, the hydrogen leakage will be greater than that shown in Table 6, but it is proposed for the present purpose to neglect this and also any correction necessary for the nitrogen or oxygen as such evolved from the coal.

TABLE 6.

Composition of Air-Free Waste Gas.		Hydrogen Leakage Expressed as Therms per Ton of Coal.
CO_2.	N_2.	
20·9	79·1	*nil*
20·5	79·5	1·4
20·0	80·0	3·2
19·5	80·5	5·2
19·0	81·0	7·3
18·5	81·5	9·6

If the heating gas contains hydrogen or methane derived from the coke, then, without any leakage, the theoretical products of combustion will contain less than 20·9 p.ct. of carbon dioxide. In fact, there is usually sufficient hydrogen in the coke to give products of combustion containing only 20·5 p.ct. of carbon dioxide, but it should be noted that in such cases the data given in Tables 6 and 7 may still be used by taking difference figures—*e.g.*, if the air-free gas contains 19·5 p.ct. of carbon dioxide, the hydrogen leakage is equivalent to 5·0 − 1·4 = 3·6 therms. (As is shown later, a very small correction is necessary when there is any leakage of water gas from steamed retorts.)

In order to calculate the total thermal equivalent of the coal-gas leakage, it is necessary to know the ratio by weight of combustible carbon to combustible hydrogen. It is assumed for the present purpose that this is 3·2, a ratio applicable to any coal gas giving 12 p.ct. of carbon dioxide in its air-free products of combustion. The calorific value of a unit weight of carbon is 0·24 times that of hydrogen, so that if hydrogen and carbon were present in the gas in elemental form, the thermal leakage due to carbon would be 3·2 × 0·24 = 0·77 times, or the total thermal leakage would be 1·77 times the leakage due to hydrogen alone.

The calorific value of the crude coal gas, however, is probably less than that of the equivalents of the elements carbon and hydrogen contained in it. From a consideration of the known heats of formation of the hydrocarbons contained in crude gas, it is concluded that the correction to be applied to the calorific value as calculated above cannot exceed 10 p.ct., and that, for the present purpose, it is justifiable and sufficiently accurate to take the total thermal leakage due to coal gas as being 1·6 times that shown as due to hydrogen alone in Table 6. The figures thus calculated are shown in Table 7.

TABLE 7.

Concentration of CO_2 in Air-Free Waste Gas.	Leakage of Coal Gas as Therms per Ton of Coal.
20·5 p.ct.	2·2
20·0 ,,	5·1
19·5 ,,	8·3
19·0 ,,	11·7
18·5 ,,	15·4

In order to facilitate the calculation of differences when the air-free products of combustion contain less than 20·9 p.ct. of carbon dioxide due to the presence of hydrogen in the coke, these results are plotted in fig. 5.

PRESSURE CONDITIONS WITHIN THE RETORT.

When the above results, and particularly those plotted in fig. 4, are considered in conjunction with the data published by Mr. E. V. Evans (Cantor Lectures, 1924), the desirability of varying the pressure conditions within any intermittently charged retort as the carbonization of the coal proceeds, becomes very obvious. The ideal would appear to be to exert a very definite pull upon the retort during the very early stages of carbonization when gas of the highest quality is being evolved from the coal with maximum velocity, and to maintain the pressure within the retort equal to, or very slightly in excess of, the gas pressure within the combustion chamber surrounding the retort during later stages when gas is being evolved at comparatively low velocity.

Such an object might be secured by providing a separate governing device for each retort. If the usual type of retort house governor was employed, this would prove to be a cumbersome arrangement. An alternative arrangement would be to sectionalize the hydraulic main and to provide a separate adjustable liquor overflow weir for each section of the main corresponding to each retort. This,

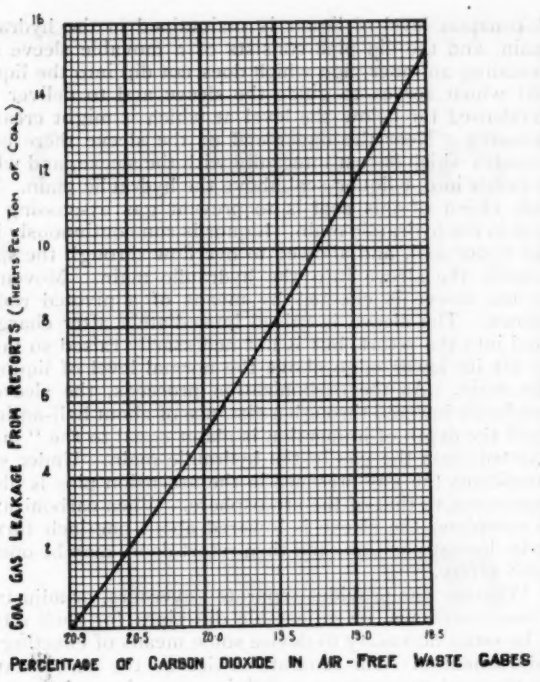

Fig. 5.

of course, assumes that one is working with sealed dip pipes. Yet another alternative is to work with a common liquor level in the hydraulic main, as in normal practice to-day, and to provide for a means of vertical adjustment of each dip pipe.

Fig. 6 illustrates one of the patterns of adjustable dip pipe which is being installed on several settings of retorts.

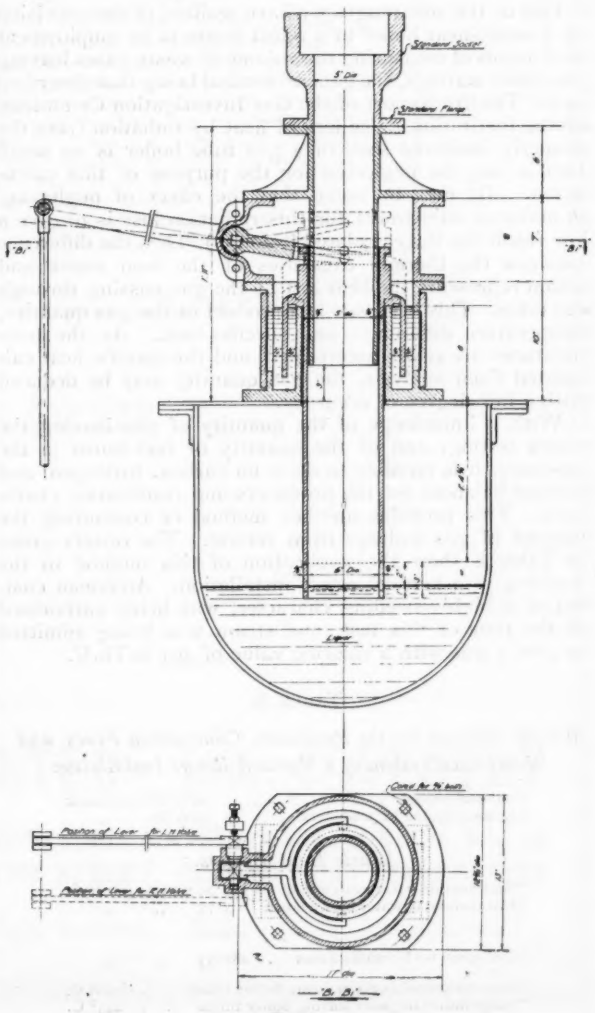

Fig. 6.

A constant level of liquor is maintained in the hydraulic main, and the dip pipe consists of a movable sleeve surrounding an inner pipe which does not dip into the liquor, but which serves to guide the sleeve and to deliver any condensed tar below the level at which it might create a nuisance. Near the upper end of the sleeve there is an annulus which is cast integrally with the sleeve, and which depends into a liquor seal above the hydraulic main. The sole object of this seal is to prevent gas by-passing the seal in the hydraulic main. Liquor is run continuously into the upper seal, and allowed to overflow through the space outside the sleeve into the hydraulic main. Movement of the sleeve is effected by means of a pivoted rod as shown. The sleeve is raised immediately after charging coal into the retort, but is not necessarily raised so far as to lift its lower edge above the normal level of liquor in the main. As the carbonization proceeds, the sleeve is gradually lowered through a distance of about half-an-inch, until the depth of immersion is about equal to the "pull" exerted upon the gas in the hydraulic main. Under such conditions the gas pressure in the ascension pipe is about equivalent to that of the atmosphere. When carbonization is complete, the sleeve is lowered about one inch further to its lowest position, and then retort doors may be opened with safety.

Whether one provides separate governors, or adjustable liquor overflows, or adjustable dip pipes for each retort, it becomes necessary to devise some means of effecting the adjustment of each separate device as the carbonization of the coal proceeds to a definite stage in each separate retort. In the first instance this adjustment is being made by hand, but the provision of a rotating shaft, common to a whole retort house, and fitted with a suitably cut cam for the actuation of the dip pipe, overflow weir, or gas governor, of each individual retort, presents only a simple problem in mechanical design outside the scope of this paper.

The Waste-Heat Boiler as a Gas Meter.

One of the advantages we have realized of the provision of a waste-heat boiler in a retort house is its employment as a means of measuring the volume of waste gases leaving the retort settings, the general method being that described in the Twelfth Report of the Gas Investigation Committee of the Institution. The loss of heat by radiation from the properly insulated shell of a gas tube boiler is so small that it may be neglected for the purpose of this calculation. (It may be noted that the effect of neglecting to make an adjustment for this radiation loss is to give a low result for the calculated leakage.) Thus the difference between the thermal capacities of the feed water and steam represents the heat lost by the gas passing through the tubes. This heat loss is a product of the gas quantity, temperature difference, and specific heat. As the temperatures are easily ascertained, and the specific heat calculated from analysis, the gas quantity may be deduced with a fair degree of accuracy.

With a knowledge of the quantity of gas leaving the retort setting, and of the quantity of fuel burnt in the producer, it is possible to draw up carbon, hydrogen, and oxygen balances for the producers and combustion chambers. This provides another method of computing the amount of gas leakage from retorts. The results given in Table 8 show the application of this method to the working of a vertical retort installation. American coal, not of a highly-swelling character, was being carbonized at the time of this test, and steam was being admitted to give a gas with a calorific value of 491 B.Th.U.

Table 8.

Weight Balance for the Producers, Combustion Flues, and Waste-Gas System of a Vertical Retort Installation.

Coal carbonized	16·9 tons per hour
Carbon gasified in producers	4996 lbs. ,,

Waste-Heat Boilers.

Total heat of water evaporated	287·20 therms per hour
Heat content of water blown down	1·73 ,, ,,
Heat given up by waste gases	288·93 ,, ,,
Temperature of gases entering boiler tubes	740° C.
Temperature of gases leaving boiler tubes	243° C.

Analyses of Waste Gases.

	By Volume.	By Weight.
CO_2	11·65 p.ct.	17·44 p.ct.
O_2	7·20 ,,	7·84 ,,
N_2	73·55 ,,	70·07 ,,
H_2O	7·60 ,,	4·65 ,,
	100·00 ,,	100·00 ,,

Ultimate Analysis of Waste Gases.

C	4·76 p.ct.
H	0·52 ,,
O	24·65 ,,
N	70·07 ,,
	100·00 ,,

Heat Content of Waste Gases.

Entering boilers (0°–740° C.)	10,080 B.Th.U. per lb. mole*
Leaving boilers (0°–243° C.)	3,220 ,, ,, ,,
Heat given up by waste gases	6,860 ,, ,, ,,

Quantity of waste gases $= \frac{28,893,000}{6,860}$ lb. moles.

Weight of carbon in waste gases $= \frac{28,893,000 \times 11{\cdot}65 \times 12}{6,860 \times 100} = 5892$ lbs.

* This is a convenient unit volume of gas for this calculation; it is equivalent to 22·4 × 454 litres, or to 357 c.ft. at 0° C. and 760 mm.

Composition of Air.

	By Volume.	By Weight.
O_2	20·67 p.ct.	23·03 p.ct.
N_2	78·22 ,,	76·27 ,,
H_2O	1·11 ,,	0·70 ,,
	100·00 ,,	100·00 ,,

Ultimate Analysis of Air.

O_2	23·65 p.ct.
N_2	76·27 ,,
H_2	0·08 ,,
	100·00

Analyses of Producer Gas.

	By Volume.	By Weight.
CO_2	5·67 p.ct.	9·49 p.ct.
O_2	0·08 ,,	0·05 ,,
CO	25·47 ,,	27·14 ,,
H_2	8·09 ,,	0·62 ,,
CH_4	0·53 ,,	0·32 ,,
N_2	55·66 ,,	59·30 ,,
H_2O	4·50 ,,	3·08 ,,
	100·00	100·00

Ultimate Analysis of Producer Gas.

C	14·46 p.ct.
H	1·04 ,,
O	25·20 ,,
N	59·30 ,,
	100·00

Weight Balances (Lbs. per Hour).

—	Waste Gas.	Producer Gas.	Secondary Air.	Leakage from Retort.
C	5,892	4,996	..	896*
H	644	360	70	214*
O	30,510	8,707	20,540	1263*
N	86,730	20,490	66,240*	..

* By difference.

Results per Ton of Coal Carbonized.

Carbon gasified in the producers	294 lbs.
Carbon leakage from retorts	53 ,,
Hydrogen ,, ,, ,,	12·7 ,,
Oxygen ,, ,, ,,	74·7 ,,
Assuming all oxygen due to water gas, the hydrogen due to water gas is	9·3 ,,
Hydrogen due to coal gas	3·4 ,,
Carbon due to coal gas (3·4 × 3·2)	10·9 ,,
Carbon due to water gas	42·1 ,,

A leakage of 42·1 lbs. of carbon in the form of water gas, whatever its composition, is equivalent to 8·5 therms per ton of coal. A leakage of 3·4 lbs. of hydrogen in the form of coal gas is equivalent to 3·3 therms.

It is interesting to note that, on an air-free basis, the waste gases contained 20·1 p.ct. of carbon dioxide, or 20 p.ct. after correction for the water gas leakage, while the theoretical calculated from the analysis of the producer gas was 20·5 p.ct. This difference corresponds to a coal gas leakage equivalent to 2·9 therms, according to the data given in fig. 5. The error of 0·4 therm is of no importance for the present purpose, but may be explained by reference to the assumptions made in calculating the data given in Table 6.

It is clear that the bulk of the leakage in this particular instance was water gas, and the application of the two

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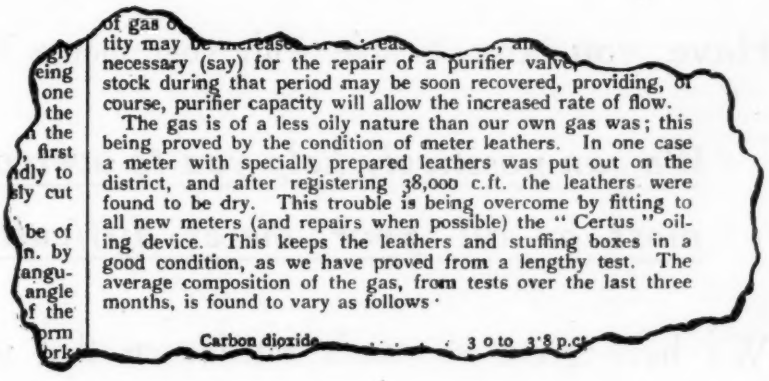

of gas o
tity may be increase
necessary (say) for the repair of a purifier valve
stock during that period may be soon recovered, providing, of course, purifier capacity will allow the increased rate of flow.

The gas is of a less oily nature than our own gas was; this being proved by the condition of meter leathers. In one case a meter with specially prepared leathers was put out on the district, and after registering 38,000 c.ft. the leathers were found to be dry. This trouble is being overcome by fitting to all new meters (and repairs when possible) the "Certus" oiling device. This keeps the leathers and stuffing boxes in a good condition, as we have proved from a lengthy test. The average composition of the gas, from tests over the last three months, is found to vary as follows:

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methods of determining the leakage provides a measure of the relative amounts of coal gas and water gas leakage from retorts.

THE PRODUCTION OF GAS IN STEAMED VERTICAL RETORTS.

The question of gas leakage from steamed vertical retorts has been considered in some detail, because, notwithstanding the undoubted merits of this system of carbonization, it has not been easy, in a study of working results, to appreciate why these are not, in certain cases, even better than they are in practice. In any analysis of results, one of the primary difficulties is to differentiate between the respective thermal yields of coal gas and water gas. The following method of analysis partially overcomes this difficulty, and is put forward in the belief that by its use the path to a still greater thermal economy in vertical retort carbonization may be indicated. In the absence of any such indication respecting the coal gas therm yield, it is difficult to suggest what steps might be taken to improve the efficiency of coal carbonization in any given set of circumstances.

The coal gas therm yield, T_c, is given by the expression :

$$T_c = H_c \left[\frac{T_m}{H_m} - \frac{T_m - T_c}{H_w}\right]$$

where H_c = the calorific value of the coal gas.
H_w = the calorific value of the water gas.
H_m = the calorific value of the mixed gas.
T_m = the total therm yield.

If all the calorific values are expressed upon an inert-free basis, H_w may be written as 320, and the above equation may be simplified thus :

$$T_c = \frac{T_m\ H_c\ (H_m - 320)}{H_m\ (H_c - 320)}$$

In this expression the values of T_m and H_m may be obtained readily from simple observations of gas volume, calorific value, and inert-content, together with coal weights such as are normally available on the plant. There are really only two unknown quantities—viz., the coal gas therm yield (T_c) and the calorific value of the inert-free coal gas (H_c). Assuming any value for the one, we may calculate the other from this equation. To facilitate such calculations, the nomogram shown in fig. 7 has been prepared.

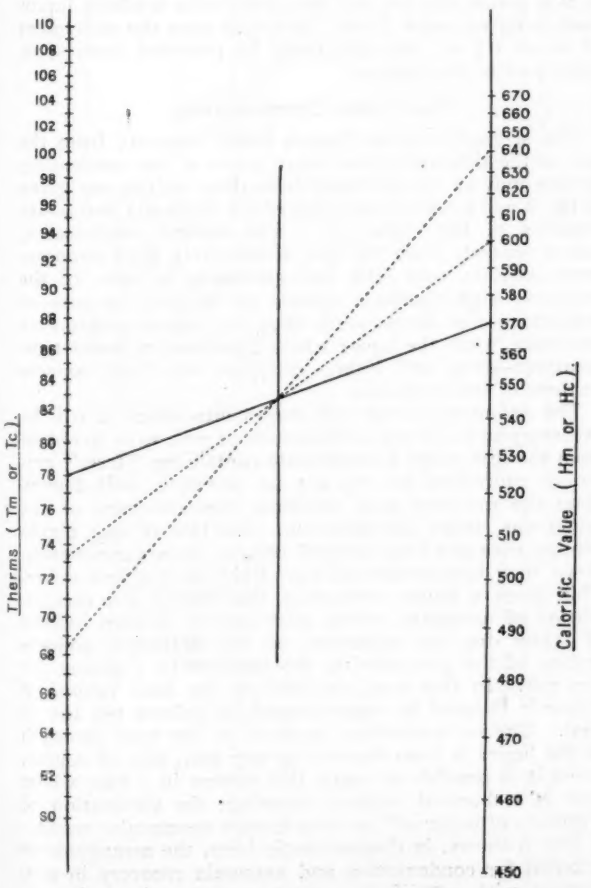


Fig. 7.

The construction of this nomogram will be appreciated more readily if it is noted that the above expression

$$T_c = \frac{T_m\ H_c\ (H_m - 320)}{H_m\ (H_c - 320)}$$

may be rewritten in the form

$$\frac{T_c}{2} = \frac{T_m}{2}\left[\frac{1 - \frac{320}{H_m}}{1 - \frac{320}{H_c}}\right]$$

or

$$\log \frac{T_c}{2} + \log\left(1 - \frac{320}{H_c}\right) = \log \frac{T_m}{2} + \log\left(1 - \frac{320}{H_m}\right)$$

Thus the scale of therms, T, is $\log \frac{T}{2}$, and the scale of calorific values, H, is $\log\left(1 - \frac{320}{H}\right)$.*

If it is supposed, for example, that a plant is giving gas equivalent to 78 therms per ton with a calorific value of 510 B.Th.U. and an inert content of 10·5 p.ct., the calorific value on an inert-free basis is 570 B.Th.U. Thus a straight line is drawn from 570 on the calorific value scale to 78 on the therm scale, and through the point of intersection with the centre line of the nomogram, the line connecting coal gas therm yield with coal gas calorific value must pass. If it is supposed that the calorific value of the inert-free coal gas is 600 B.Th.U., then 73·3 therms are due to coal gas as distinct from water gas. If it is supposed that the calorific value of the inert-free coal gas is 640 B.Th.U., then only 68·4 therms are due to coal gas.

It may be noted also that if it is assumed that with altered steaming conditions no change takes place in the yield of straight coal gas, then the straight line connecting the altered calorific value with the new therm yield must pass through the same point of intersection on the centre line.

This nomogram has been used for the analysis of working results obtained from our vertical retort installations under different conditions, and a few results are set forth in Table 9 for the purpose of illustrating this method of study of results.

TABLE 9.

—	Calorific Value of Gas.	Inerts, P.Ct.	Calorific Value of Inert Free Gas (Hm).	Total Therms.	Hc.	Coal Gas, Therms.
Example 1	491·3	13·45	567·6	81·5	640	71·10
					or 620	73·5
					or 600	76·2
,, 2	488·0	13·8	566·0	79·28	640	68·9
					or 620	71·2
					or 600	73·7
,, 3	508·0	10·65	568·5	77·62	640	67·8
					or 620	70·1
					or 600	72·7
,, 4	495·7	10·1	551·3	75·0	640	62·9
					or 620	65·0
					or 600	67·4

Example 1 relates to the same test as does Table 8. As already stated, there was reason to believe that the coal gas leakage was very small, and it will be seen that the yield of coal gas, as distinct from water gas, is reasonably high, whatever quality of coal gas is assumed.

Example 2 relates to the carbonization of Yorkshire coal, and Examples 3 and 4 relate to the carbonization of Durham coal. It will be seen that the thermal yields of coal gas from Durham coal are considerably lower than might have been expected. The complete explanation is a matter for further investigation, but already it may be said that, from analyses of the waste gases coming from these retort settings when carbonizing Durham coal, there is reason to believe that there is considerable leakage of coal gas from the retorts. It appears that the pressure conditions within the retort must be quite different when carbonizing a more highly swelling coal than when carbonizing a Yorkshire coal.

It is suggested that a useful purpose would be served

* By inverting either of these scales a simple slide rule may be constructed ; an illustration of such a slide rule appears in Appendix 1

if those who have facilities for doing so would apply the above methods to distinguish between coal gas and water gas passing either into the gas-mains or into the combustion chambers, in cases where either screened or blended coals are being carbonized, so that the results may be compared with those obtained when carbonizing unscreened Durham coals.

Ammonia Recovery.

General interest in all questions associated with ammoniacal liquor has been stimulated not only by a realization of the necessity for making a stronger liquor so as to economize in transport and distillation charges, but also by the difficulties experienced in certain localities in connection with the disposal of effluent liquors.

Owing to the distance which separates some of our works from the Ammonia Products Works, we have been particularly interested in the possibility of reducing the charges for transport of liquor by increasing the strength of the liquor recovered at the gas-works. Whatever the amount of ammonia recovered may be, the bulk of liquor produced depends upon the moisture content of the gas leaving the retort and the amount of water used in the washing system. The minimum quantity of water which is required for the complete removal of ammonia can only be determined from a knowledge of the distribution of ammonia between gas and ammoniacal liquor under the conditions of temperature and concentration which exist in the recovery plant.

The general principles of ammonia washing are, of course, widely appreciated, but there appears to be a definite lack of quantitative information. Indeed, we have found it necessary to determine for ourselves the strength of liquor in equilibrium with gas containing different concentrations of ammonia at different temperatures.

The results of this work are summarized in fig. 8. Each

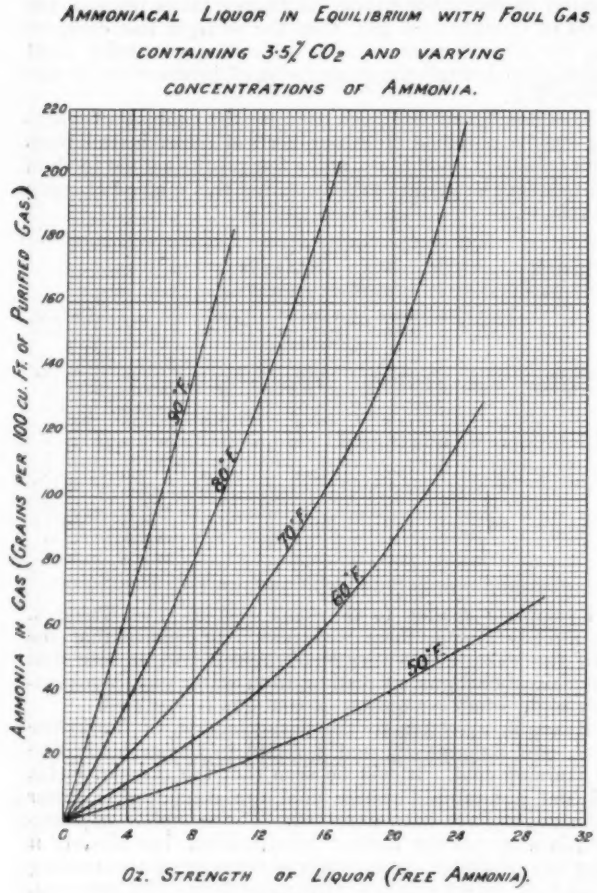


Fig. 8.

of the curves shows the relationship between the "free" ammonia content of liquor in equilibrium with gas of a given ammonia concentration at a definite temperature. It should be explained that, in this case, the gas was derived from a vertical retort plant and that it contained about 3·5 p.ct. of carbon dioxide; it is proposed in due course to determine the effect of a change in the carbon-dioxide concentration upon the partition of ammonia between gas and liquor.

A study of the curves given in Fig. 8 emphasizes the importance of thoroughly cooling the gas at the inlet to the ammonia washing plant, since, for example, washing gas with a liquor containing "free" ammonia equivalent to 2 oz. strength would reduce the ammonia content of the gas to 6 grains per 100 c.ft. at 60° Fahr. but only to 34 grains per 100 c.ft. at 90° Fahr.

Table 10 gives the theoretical quantities of water in gallons per ton of coal which it would be necessary to use for the complete extraction of ammonia from coal gas containing 3·5 p.ct. of carbon dioxide at different temperatures, and for different concentrations of ammonia in the gas entering the washing system. (It is assumed that the yield of gas is equivalent to 15,200 c.ft. per ton of coal.)

Table 10.

Temperature.	Ammonia in Gas Entering Washers (Grains per 100 C.Ft.				
	100.	120.	140.	160.	180.
	Galls.	Galls.	Galls.	Galls.	Galls.
60° Fahr. . . .	4·5	4·9	5·2	5·6	..
70° ,, . . .	6·4	6·7	7·1	7·5	8·0
80° ,, . . .	10·4	10·7	11·1	11·4	11·8
90° ,, . . .	17·0	17·2	17·5	17·8	18·0

Obviously, in order to obtain a strong liquor, it is necessary to ensure that the temperature of both gas and liquor in the ammonia recovery plant is as low as possible, and that the retort house circulation system and condensers are so operated that the ammonia concentration of the gas entering the washers is also as low as possible.

Further consideration of the data given respecting the equilibrium between gas and liquor shows that, if it is permissible to allow (say) a maximum of 5 grains of ammonia per 100 c.ft. of gas to pass forward from the ammonia washing system to the oxide of iron purification system (the merits of which practice it is not proposed to discuss at present), it would be possible to recover the rest of the ammonia from the gas without the introduction of fresh water for washing, provided that the temperature is kept reasonably low and provided that a washing liquor containing no more "free" ammonia than the equivalent of about 1·5 oz. strength could be procured from some other part of the system.

Fractional Condensation.

The strengths of the liquors which separate from the gas in the different temperature zones of the condensing system may all be calculated from data such as are given in fig. 8 and from a knowledge of the ammonia and water contents of the crude gas. The earliest condensates, which separate from the gas at relatively high temperatures, contain very little free ammonia, in spite of the relatively high ammonia content of the gas, because of the influence of temperature upon the vapour-pressure of ammonia, while the liquor which condenses at lower temperatures—(say) 60° Fahr.—contains very high concentrations of free ammonia.

The definition of the two stages into which it will be necessary to divide the condensation of gas, so as to obtain from the first stage a condensate containing "free" ammonia equivalent to only 1·5 oz. strength, will depend upon the moisture and ammonia concentrations of the crude gas under consideration. On two of our plants dealing with gas from vertical retorts, we are condensing down to a temperature of 130° Fahr. in the first stage. This gives a liquor containing the desired low concentration of ammonia, which after cooling is used instead of water for the reduction of the ammonia concentration of the gas entering the purifiers to 5 grains per 100 c.ft. In this way, the bulk of the final volume of liquor is reduced by approximately 6 gallons per ton of coal. The corresponding increase in the total strength of the liquor is from 8·9 ozs. to 10·7 ozs., but, of course, when it is possible to apply this system in a case where coal is carbonized without steaming; the elimination of 6 gallons of water will produce a more spectacular result.

Fig. 9 shows, in diagrammatic form, the arrangements adopted for condensation and ammonia recovery in connection with one of the recent reconstruction schemes.

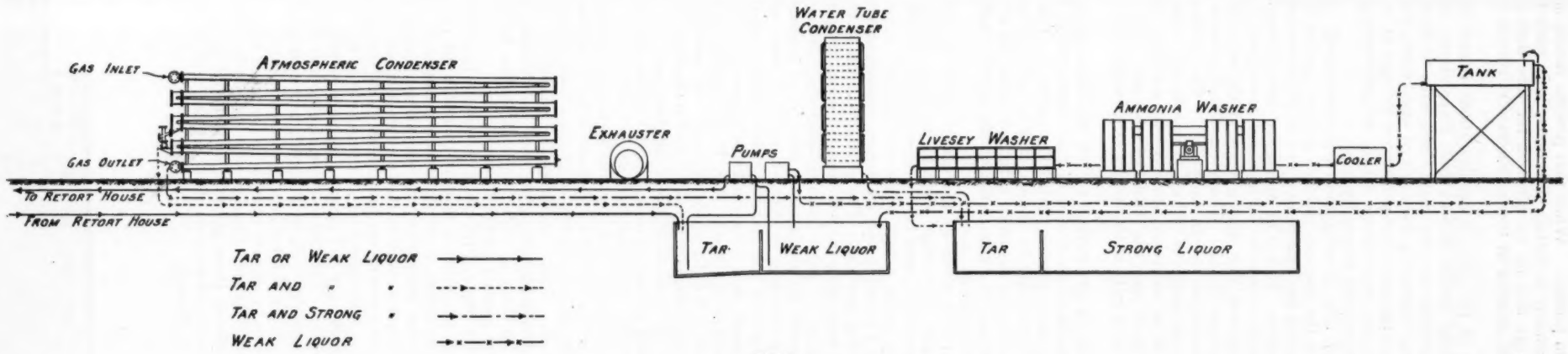


FIG. 9.

The gas passes through atmospheric condensers, the exhauster, and then water-tube condensers. This sequence of plant is chosen to give as low a temperature as possible in the gas entering the washing plant, combined with economy of power and of cooling water. In the diagram it is assumed that gas is passing downwards through the atmospheric condenser, but in fact the various connections have been duplicated so that the gas may be passed either upwards or downwards.

The weak ammoniacal liquor which condenses in the first limbs of the atmospheric condenser is not allowed to mingle with the stronger liquor condensing lower down, but is drawn off separately and run through a suitable seal into the tar tank, whence it overflows into the weak liquor tank. The strong liquor condensing in the lower limbs of the atmospheric condenser, and in the water-tube condenser, is passed through a tar separating tank direct to the strong liquor tank, and is not re-circulated.

Either tar or weak liquor may be circulated through the hydraulic mains, and it will be noted that when tar is circulated provision is made for a moderate degree of washing of the tar by weak liquor, as both flow into the tar tank at the same point, whereby any undue accumulation of solid ammonium chloride in the tar is prevented.

The whole of the excess weak liquor is passed through a cooler, and then through the washers in series to the strong liquor tank, after which it is not recirculated. An overhead feed tank with overflow return pipe is interposed as shown, in order to secure a more regular flow of liquor through the washers than can be obtained from a pump direct.

The importance of thorough cooling of the liquor entering the washers has been emphasized already. It is equally important to see that the fractionation of the liquor in the atmospheric condenser is carried out at such a temperature that the "free" ammonia content of the weak liquor fraction does not exceed the equivalent of 1·5 oz. strength, otherwise excessive quantities of ammonia will leave the washers in the gas stream.

Furthermore, if liquor containing much "free" ammonia be returned to the hydraulic main, the ammonia concentration of the gas will be increased and the whole system de-arranged. The control of the temperature at the point where fractionation of the liquor is effected is rendered quite simple by the provision of gas valves so that one, two, or more vertical tiers of the atmospheric condenser may be put out of action.

So far as can be ascertained at present this system gives a liquor with a reasonably low concentration of the toxic constituents which are found ultimately in the sulphate plant effluent. Certainly the volume of effluent is reduced to a minimum, since no water is used for washing the gas.

The Manufacture of Carburetted Water Gas.

In any consideration of the manufacture of carburetted water gas, it is not uncommon to express the efficiency of oil cracking as an enrichment effect in terms of British thermal units per cubic foot of gas per gallon of oil. It is often assumed that a plant is working efficiently if the increase in the calorific value of the blue water gas is equivalent to not less than 100 B.Th.U. per c.ft. for every gallon of oil used per 1000 c.ft. of total gas made. While this may be a useful guide in many cases, it is found that it may give misleading results, owing to variations in calorific value of blue water gas resulting from variations in the proportion of inert constituents in the gas.

There are one or two methods of calculation from gas analyses which overcome this difficulty. The Gas Investigation Committee of this Institution, and also a Committee of the American Gas Association, have made use of such methods. While these methods are eminently suitable for research work, and are so used by us, it is found that they are a little cumbersome for the purpose of routine observations of plant working. The following statement of our method of differentiation between the thermal yields of blue water gas and of gas derived from the enriching oil may be of interest.

At the present time we normally possess the following data:

(*a*) The coke used in lbs. per 1000 c.ft. of carburetted water gas.
(*b*) The oil used in gallons per 1000 c.ft. of carburetted water gas.
(*c*) The calorific value of the carburetted water gas in B.Th.U. per c.ft.
(*d*) The percentage of inerts in the carburetted water gas.

By adoption of the following method of calculation, it is possible to determine the yield of therms per gallon of oil, as well as the yield of therms per unit weight of coke, and each result is free from any error due to variations in the proportion of inert constituents in the gas.

It is assumed that the calorific value of blue water gas is 325 B.Th.U. per c.ft. on an inert-free basis. This is equivalent to the assumption that the gas contains 0·5 p.ct. of methane.

It is also assumed that each gallon of oil gives 70 c.ft. of oil gas in excess of the volume of hydrogen absorbed by hydrogenation reactions. This is based upon recent work in the laboratory and on one or two of our plants.

From the data *a*, *b*, *c*, and *d*, indicated above, the volume of blue water gas per 1000 c.ft. of carburetted water gas is equivalent to

$$(1000 - 70b - 10d) \text{ c.ft.}$$

Thus the thermal value of blue water gas per 1000 c.ft of carburetted water gas is equivalent to

$$0{\cdot}0325\,(100 - 7b - a) = x \text{ therms.}$$

To facilitate the following simple calculations, tables giving values of this expression are included in Appendix 2.

The thermal yield per gallon of oil used is equivalent to

$$\frac{0{\cdot}01c - x}{b} \text{ therms.}$$

The thermal yield per 1000 lbs. of coke is equivalent to

$$\frac{1000\,x}{a} \text{ therms.}$$

It is realized that the net volume of oil gas given by each gallon of oil is subject to variation due to either variation in the actual volume of gas resulting from the oil or to variation in the volume of hydrogen absorbed during the cracking of the oil. In fact, our investigations show that the net volume of oil gas may vary from 50 c.ft. to 80 c.ft. per gallon, but such variations make a comparatively slight difference to the results of the above calculation.

Table 11 shows some of our working results analyzed in this manner.

TABLE 11.

—		1.	2.	3.
Coke used per 1000 c.ft., lbs. .	(*a*)	37·38	35·31	36·19
Oil used per 1000 c.ft., galls .	(*b*)	0·65	1·62	1·30
Calorific value of gas . . .	(*c*)	355·9	459·8	421·5
Inerts in gas, p.ct.	(*d*)	14·4	9·7	10·1
Therms in B.W.G.	(*x*)	2·635	2·567	2·626
Therms from oil.		0·924	2·031	1·589
Therms per gallon of oil . . .		1·42	1·25	1·22
Therms per 1000 lbs. of coke. .		70·5	72·7	72·6

Generally such results show variations in the thermal yield of gas from coke which are difficult to explain with our present knowledge. The yield probably depends in a large measure upon the quality of the coke, a subject upon which more investigation is required before it can be discussed in such a paper as this.

Example No. 1 in Table 11 shows the high efficiency of cracking of oil which we find is usually obtained when only small quantities of oil are used. Example No. 2 is chosen to illustrate the lower efficiency of oil cracking resulting from the use of larger quantities of oil; and Example No. 3 is chosen as being typical of results obtained when working with the back-run process. While that process results in efficiency and economy in certain directions, it is subject to the disadvantage that by its adoption the time during which oil may be cracked in the carburettor is considerably reduced.

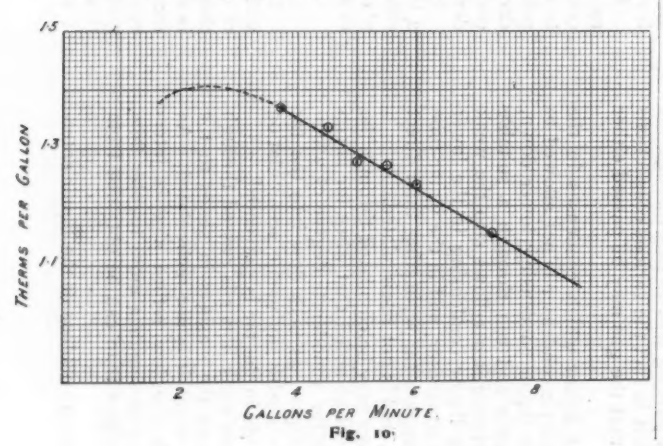


Fig. 10.

In the course of the general considerations raised by analyses of working results such as those given above, we were led to determine on one plant, and with uniform general conditions respecting the cycle of operations, the temperatures, &c., the relationship between the rate of injection of oil into the carburettor during the gas-making run and the thermal yield of gas from oil.

The results of this investigation are summarized in fig. 10, in which the thermal yield of gas per gallon of oil is plotted against the rate of injection of oil expressed in gallons per minute. It will be noted that the efficiency falls off considerably when the oil is added more quickly. It should be explained that during these trials no steps were taken to preheat the oil. The effect of such practice it is hoped to investigate at an early date. The broken part of the curve showing the falling-off in efficiency with very low rates of oil injection, due to over-cracking of the vapours, is based upon the results of laboratory work, and has not yet been fully confirmed by large-scale observations.

When the effect of preheating the oil has been determined, and when more positive data have been obtained for the efficiency of oil cracking with low rates of oil injection, it will be possible by means of a curve such as is exemplified in fig. 10 to make a further study of the back-run process and to compare the saving of coke with the increased consumption of oil.

In addition to this study of the manufacture of carburetted water gas on a large scale by methods which, it should be appreciated, have been determined by the absence of anything in the nature of an experimental water gas plant, we are carrying out laboratory investigations on the oil cracking process. The primary object is to secure such data respecting the influence of various factors upon the process as will permit of a detailed study of carburettor and superheater design. It may be of interest to note that in the course of the work it has been observed that under standardized conditions the maximum thermal yield of gas depends in a very marked degree upon the chemical composition of the oil. Dr. R. H. Griffith has recently described (J.S.C.I., 1928, **47**, 21T) the methods of chemical analyses which he has developed in the research laboratory for the purpose of this investigation, and many oils have now been submitted to chemical analysis and to gas-making tests on a laboratory scale. It has been found that those oils which give low thermal yields of gas are characterized by a low content of open-chain hydrocarbons and a correspondingly high content of hydrocarbons having a cyclic structure. This conclusion is supported by analyses of oils persistently giving high and low efficiencies respectively in working practice, the efficiencies being determined by the method outlined above.

In preparing this paper, little or no reference has been made to a number of chemical matters to which full consideration has been given at recent technical conferences. Also the very great temptation to speculate regarding possible future chemical work in the industry has been resisted. The applications of active charcoal, new methods of gas purification, hydrogenation and synthesis of hydrocarbons, for example, are still matters for further investigation and research. The illustrations of chemical work which have been chosen will, it is hoped, prove to be of more immediate practical interest to the gas maker.

The author desires to express his thanks for much advice received from Mr. Thomas Hardie, who originally suggested that a paper on these general lines should be prepared, and for the help of several colleagues and assistants, particularly Dr. S. Pexton.

APPENDIX 1.

APPENDIX 2.

Table showing the Equivalent in Therms of the Blue Water Gas contained in 1000 C.Ft. of Carburetted Water Gas, which is 0·0325 (100 − 7b − d), when b is the number of Gallons of Oil used per 1000 C.Ft. of Carburetted Water Gas, and d is the Percentage of Inerts in the Carburetted Water Gas.

Gallons Oil Used per 1000 C.Ft. C.W.G.	P.Ct. Inerts in Carburetted Water Gas.													Gallons Oil Used per 1000 C.Ft. C.W.G.
	9·0	9·1	9·2	9·3	9·4	9·5	9·6	9·7	9·8	9·9	10·0	10·1	10·2	
0·0	2·958	2·954	2·951	2·948	2·945	2·941	2·938	2·935	2·932	2·928	2·925	2·922	2·919	0·0
0·1	2·935	2·932	2·928	2·925	2·922	2·919	2·915	2·912	2·909	2·906	2·902	2·899	2·896	0·1
0·2	2·912	2·909	2·906	2·902	2·899	2·896	2·893	2·889	2·886	2·883	2·880	2·876	2·873	0·2
0·3	2·889	2·886	2·883	2·880	2·876	2·873	2·870	2·867	2·863	2·860	2·857	2·854	2·850	0·3
0·4	2·867	2·863	2·860	2·857	2·854	2·850	2·847	2·844	2·841	2·837	2·834	2·831	2·828	0·4
0·5	2·844	2·841	2·837	2·834	2·831	2·828	2·824	2·821	2·818	2·815	2·811	2·808	2·805	0·5
0·6	2·821	2·818	2·815	2·811	2·808	2·805	2·802	2·798	2·795	2·792	2·789	2·785	2·782	0·6
0·7	2·798	2·795	2·792	2·789	2·785	2·782	2·779	2·776	2·772	2·769	2·766	2·763	2·759	0·7
0·8	2·776	2·772	2·769	2·766	2·763	2·759	2·756	2·753	2·750	2·746	2·743	2·740	2·737	0·8
0·9	2·753	2·750	2·746	2·743	2·740	2·737	2·733	2·730	2·727	2·724	2·720	2·717	2·714	0·9
1·0	2·730	2·727	2·724	2·720	2·717	2·714	2·711	2·707	2·704	2·701	2·698	2·694	2·691	1·0
1·1	2·707	2·704	2·701	2·698	2·694	2·691	2·688	2·685	2·681	2·678	2·675	2·672	2·668	1·1
1·2	2·685	2·681	2·678	2·675	2·672	2·668	2·665	2·662	2·659	2·655	2·652	2·649	2·646	1·2
1·3	2·662	2·659	2·655	2·652	2·649	2·646	2·642	2·639	2·636	2·633	2·629	2·626	2·623	1·3
1·4	2·639	2·636	2·633	2·629	2·626	2·623	2·620	2·616	2·613	2·610	2·607	2·603	2·600	1·4
1·5	2·616	2·613	2·610	2·607	2·603	2·600	2·597	2·594	2·590	2·587	2·584	2·581	2·577	1·5
1·6	2·594	2·590	2·587	2·584	2·581	2·577	2·574	2·571	2·568	2·564	2·561	2·558	2·555	1·6
1·7	2·571	2·568	2·564	2·561	2·558	2·555	2·551	2·548	2·545	2·542	2·538	2·535	2·532	1·7
1·8	2·548	2·545	2·542	2·538	2·535	2·532	2·529	2·525	2·522	2·519	2·516	2·512	2·509	1·8
1·9	2·525	2·522	2·519	2·516	2·512	2·509	2·506	2·503	2·499	2·496	2·493	2·490	2·486	1·9
2·0	2·503	2·499	2·496	2·493	2·490	2·486	2·483	2·480	2·477	2·473	2·470	2·467	2·464	2·0
2·1	2·480	2·477	2·473	2·470	2·467	2·464	2·460	2·457	2·454	2·451	2·447	2·444	2·441	2·1
2·2	2·457	2·454	2·451	2·447	2·444	2·441	2·438	2·434	2·431	2·428	2·425	2·421	2·418	2·2
2·3	2·434	2·431	2·428	2·425	2·421	2·418	2·415	2·412	2·408	2·405	2·402	2·399	2·395	2·3
2·4	2·412	2·408	2·405	2·402	2·399	2·395	2·392	2·389	2·386	2·382	2·379	2·376	2·373	2·4

Gallons Oil Used per 1000 C.Ft. C.W.G.	P.Ct. Inerts in Carburetted Water Gas.													Gallons Oil Used per 1000 C.Ft. C.W.G.
	10·3	10·4	10·5	10·6	10·7	10·8	10·9	11·0	11·1	11·2	11·3	11·4	11·5	
0·0	2·915	2·912	2·909	2·906	2·902	2·899	2·896	2·893	2·889	2·886	2·883	2·880	2·876	0·0
0·1	2·893	2·889	2·886	2·883	2·880	2·876	2·873	2·870	2·867	2·863	2·860	2·857	2·854	0·1
0·2	2·870	2·867	2·863	2·860	2·857	2·854	2·850	2·847	2·844	2·841	2·837	2·834	2·831	0·2
0·3	2·847	2·844	2·841	2·837	2·834	2·831	2·828	2·824	2·821	2·818	2·815	2·811	2·808	0·3
0·4	2·824	2·821	2·818	2·815	2·811	2·808	2·805	2·802	2·798	2·795	2·792	2·789	2·785	0·4
0·5	2·802	2·798	2·795	2·792	2·789	2·785	2·782	2·779	2·776	2·772	2·769	2·766	2·763	0·5
0·6	2·779	2·776	2·772	2·769	2·766	2·763	2·759	2·756	2·753	2·750	2·746	2·743	2·740	0·6
0·7	2·756	2·753	2·750	2·746	2·743	2·740	2·737	2·733	2·730	2·727	2·724	2·720	2·717	0·7
0·8	2·733	2·730	2·727	2·724	2·720	2·717	2·714	2·711	2·707	2·704	2·701	2·698	2·694	0·8
0·9	2·711	2·707	2·704	2·701	2·698	2·694	2·691	2·688	2·685	2·681	2·678	2·675	2·672	0·9
1·0	2·688	2·685	2·681	2·678	2·675	2·672	2·668	2·665	2·662	2·659	2·655	2·652	2·649	1·0
1·1	2·665	2·662	2·659	2·655	2·652	2·649	2·646	2·642	2·639	2·636	2·633	2·629	2·626	1·1
1·2	2·642	2·639	2·636	2·633	2·629	2·626	2·623	2·620	2·616	2·613	2·610	2·607	2·603	1·2
1·3	2·620	2·616	2·613	2·610	2·607	2·603	2·600	2·597	2·594	2·590	2·587	2·584	2·581	1·3
1·4	2·597	2·594	2·590	2·587	2·584	2·581	2·577	2·574	2·571	2·568	2·564	2·561	2·558	1·4
1·5	2·574	2·571	2·568	2·564	2·561	2·558	2·555	2·551	2·548	2·545	2·542	2·538	2·535	1·5
1·6	2·551	2·548	2·545	2·542	2·538	2·535	2·532	2·529	2·525	2·522	2·519	2·516	2·512	1·6
1·7	2·529	2·525	2·522	2·519	2·516	2·512	2·509	2·506	2·503	2·499	2·496	2·493	2·490	1·7
1·8	2·506	2·503	2·499	2·496	2·493	2·490	2·486	2·483	2·480	2·477	2·473	2·470	2·467	1·8
1·9	2·483	2·480	2·477	2·473	2·470	2·467	2·464	2·460	2·457	2·454	2·451	2·447	2·444	1·9
2·0	2·460	2·457	2·454	2·451	2·447	2·444	2·441	2·438	2·434	2·431	2·428	2·425	2·421	2·0
2·1	2·438	2·434	2·431	2·428	2·425	2·421	2·418	2·415	2·412	2·408	2·405	2·402	2·399	2·1
2·2	2·415	2·412	2·408	2·405	2·402	2·399	2·395	2·392	2·389	2·386	2·382	2·379	2·376	2·2
2·3	2·392	2·389	2·386	2·382	2·379	2·376	2·373	2·369	2·366	2·363	2·360	2·356	2·353	2·3
2·4	2·369	2·366	2·363	2·360	2·356	2·353	2·350	2·347	2·343	2·340	2·337	2·334	2·330	2·4

Gallons Oil Used per 1000 C.Ft. C.W.G.	P.Ct. Inerts in Carburetted Water Gas.													Gallons Oil Used per 1000 C.Ft. C.W.G.
	11·6	11·7	11·8	11·9	12·0	12·1	12·2	12·3	12·4	12·5	12·6	12·7	12·8	
0·0	2·873	2·870	2·867	2·863	2·860	2·857	2·854	2·850	2·847	2·844	2·841	2·837	2·834	0·0
0·1	2·850	2·847	2·844	2·841	2·837	2·834	2·831	2·828	2·824	2·821	2·818	2·815	2·811	0·1
0·2	2·828	2·824	2·821	2·818	2·815	2·811	2·808	2·805	2·802	2·798	2·795	2·792	2·789	0·2
0·3	2·805	2·802	2·798	2·795	2·792	2·789	2·785	2·782	2·779	2·776	2·772	2·769	2·766	0·3
0·4	2·782	2·779	2·776	2·772	2·769	2·766	2·763	2·759	2·756	2·753	2·750	2·746	2·743	0·4
0·5	2·759	2·756	2·753	2·750	2·746	2·743	2·740	2·737	2·733	2·730	2·727	2·724	2·720	0·5
0·6	2·737	2·733	2·730	2·727	2·724	2·720	2·717	2·714	2·711	2·707	2·704	2·701	2·698	0·6
0·7	2·714	2·711	2·707	2·704	2·701	2·698	2·694	2·691	2·688	2·685	2·681	2·678	2·675	0·7
0·8	2·691	2·688	2·685	2·681	2·678	2·675	2·672	2·668	2·665	2·662	2·659	2·655	2·652	0·8
0·9	2·668	2·665	2·662	2·659	2·655	2·652	2·649	2·646	2·642	2·639	2·636	2·633	2·629	0·9
1·0	2·646	2·642	2·639	2·636	2·633	2·629	2·626	2·623	2·620	2·616	2·613	2·610	2·607	1·0
1·1	2·623	2·620	2·616	2·613	2·610	2·607	2·603	2·600	2·597	2·594	2·590	2·587	2·584	1·1
1·2	2·600	2·597	2·594	2·590	2·587	2·584	2·581	2·577	2·574	2·571	2·568	2·564	2·561	1·2
1·3	2·577	2·574	2·571	2·568	2·564	2·561	2·558	2·555	2·551	2·548	2·545	2·542	2·538	1·3
1·4	2·555	2·551	2·548	2·545	2·542	2·538	2·535	2·532	2·529	2·525	2·522	2·519	2·516	1·4
1·5	2·532	2·529	2·525	2·522	2·519	2·516	2·512	2·509	2·506	2·503	2·499	2·496	2·493	1·5
1·6	2·509	2·506	2·503	2·499	2·496	2·493	2·490	2·486	2·483	2·480	2·477	2·473	2·470	1·6
1·7	2·486	2·483	2·480	2·477	2·473	2·470	2·467	2·464	2·460	2·457	2·454	2·451	2·447	1·7
1·8	2·464	2·460	2·457	2·454	2·451	2·447	2·444	2·441	2·438	2·434	2·431	2·428	2·425	1·8
1·9	2·441	2·438	2·434	2·431	2·428	2·425	2·421	2·418	2·415	2·412	2·408	2·405	2·402	1·9
2·0	2·418	2·415	2·412	2·408	2·405	2·402	2·399	2·395	2·392	2·389	2·386	2·382	2·379	2·0
2·1	2·395	2·392	2·389	2·386	2·382	2·379	2·376	2·373	2·369	2·366	2·363	2·360	2·356	2·1
2·2	2·373	2·369	2·366	2·363	2·360	2·356	2·353	2·350	2·347	2·343	2·340	2·337	2·334	2·2
2·3	2·350	2·347	2·343	2·340	2·337	2·334	2·330	2·327	2·324	2·321	2·317	2·314	2·311	2·3
2·4	2·327	2·324	2·321	2·317	2·314	2·311	2·308	2·304	2·301	2·298	2·295	2·291	2·288	2·4

APPENDIX 2 (*continued*).

Gallons Oil Used per 1000 C.Ft. C.W.G.	P.Ct. Inerts in Carburetted Water Gas.													Gallons Oil Used per 1000 C.Ft. C.W.G.
	12·9	13·0	13·1	13·2	13·3	13·4	13·5	13·6	13·7	13·8	13·9	14·0	14·1	
0·0	2·831	2·828	2·824	2·821	2·818	2·815	2·811	2·808	2·805	2·802	2·798	2·795	2·792	0·0
0·1	2·808	2·805	2·802	2·798	2·795	2·792	2·789	2·785	2·782	2·779	2·776	2·772	2·769	0·1
0·2	2·785	2·782	2·779	2·776	2·772	2·769	2·766	2·763	2·759	2·756	2·753	2·750	2·746	0·2
0·3	2·763	2·759	2·756	2·753	2·750	2·746	2·743	2·740	2·737	2·733	2·730	2·727	2·724	0·3
0·4	2·740	2·737	2·733	2·730	2·727	2·724	2·720	2·717	2·714	2·711	2·707	2·704	2·701	0·4
0·5	2·717	2·714	2·711	2·707	2·704	2·701	2·698	2·694	2·691	2·688	2·685	2·681	2·678	0·5
0·6	2·694	2·691	2·688	2·685	2·681	2·678	2·675	2·672	2·668	2·665	2·662	2·659	2·655	0·6
0·7	2·672	2·668	2·665	2·662	2·659	2·655	2·652	2·649	2·646	2·642	2·639	2·636	2·633	0·7
0·8	2·649	2·646	2·642	2·639	2·636	2·633	2·629	2·626	2·623	2·620	2·616	2·613	2·610	0·8
0·9	2·626	2·623	2·620	2·616	2·613	2·610	2·607	2·603	2·600	2·597	2·594	2·590	2·587	0·9
1·0	2·603	2·600	2·597	2·594	2·590	2·587	2·584	2·581	2·577	2·574	2·571	2·568	2·564	1·0
1·1	2·581	2·577	2·574	2·571	2·568	2·564	2·561	2·558	2·555	2·551	2·548	2·545	2·542	1·1
1·2	2·558	2·555	2·551	2·548	2·545	2·542	2·538	2·535	2·532	2·529	2·525	2·522	2·519	1·2
1·3	2·535	2·532	2·529	2·525	2·522	2·519	2·516	2·512	2·509	2·506	2·503	2·499	2·496	1·3
1·4	2·512	2·509	2·506	2·503	2·499	2·496	2·493	2·490	2·486	2·483	2·480	2·477	2·473	1·4
1·5	2·490	2·486	2·483	2·480	2·477	2·473	2·470	2·467	2·464	2·460	2·457	2·454	2·451	1·5
1·6	2·467	2·464	2·460	2·457	2·454	2·451	2·447	2·444	2·441	2·438	2·434	2·431	2·428	1·6
1·7	2·444	2·441	2·438	2·434	2·431	2·428	2·425	2·421	2·418	2·415	2·412	2·408	2·405	1·7
1·8	2·421	2·418	2·415	2·412	2·408	2·405	2·402	2·399	2·395	2·392	2·389	2·386	2·382	1·8
1·9	2·399	2·395	2·392	2·389	2·386	2·382	2·379	2·376	2·373	2·369	2·366	2·363	2·360	1·9
2·0	2·376	2·373	2·369	2·366	2·363	2·360	2·356	2·353	2·350	2·347	2·343	2·340	2·337	2·0
2·1	2·353	2·350	2·347	2·343	2·340	2·337	2·334	2·330	2·327	2·324	2·321	2·317	2·314	2·1
2·2	2·330	2·327	2·324	2·321	2·317	2·314	2·311	2·308	2·304	2·301	2·298	2·295	2·291	2·2
2·3	2·308	2·304	2·301	2·298	2·295	2·291	2·288	2·285	2·282	2·278	2·275	2·272	2·269	2·3
2·4	2·285	2·282	2·278	2·275	2·272	2·269	2·265	2·262	2·259	2·256	2·252	2·249	2·246	2·4

Gallons Oil Used per 1000 C.Ft. C.W.G.	P.Ct. Inerts in Carburetted Water Gas.													Gallons Oil Used per 1000 C.Ft. C.W.G.
	14·2	14·3	14·4	14·5	14·6	14·7	14·8	14·9	15·0	15·1	15·2	15·3	15·4	
0·0	2·789	2·785	2·782	2·779	2·776	2·772	2·769	2·766	2·763	2·759	2·756	2·753	2·750	0·0
0·1	2·766	2·763	2·759	2·756	2·753	2·750	2·746	2·743	2·740	2·737	2·733	2·730	2·727	0·1
0·2	2·743	2·740	2·737	2·733	2·730	2·727	2·724	2·720	2·717	2·714	2·711	2·707	2·704	0·2
0·3	2·720	2·717	2·714	2·711	2·707	2·704	2·701	2·698	2·694	2·691	2·688	2·685	2·681	0·3
0·4	2·698	2·694	2·691	2·688	2·685	2·681	2·678	2·675	2·672	2·668	2·665	2·662	2·659	0·4
0·5	2·675	2·672	2·668	2·665	2·662	2·659	2·655	2·652	2·649	2·646	2·642	2·639	2·636	0·5
0·6	2·652	2·649	2·646	2·642	2·639	2·636	2·633	2·629	2·626	2·623	2·620	2·616	2·613	0·6
0·7	2·629	2·626	2·623	2·620	2·616	2·613	2·610	2·607	2·603	2·600	2·597	2·594	2·590	0·7
0·8	2·607	2·603	2·600	2·597	2·594	2·590	2·587	2·584	2·581	2·577	2·574	2·571	2·568	0·8
0·9	2·584	2·581	2·577	2·574	2·571	2·568	2·564	2·561	2·558	2·555	2·551	2·548	2·545	0·9
1·0	2·561	2·558	2·555	2·551	2·548	2·545	2·542	2·538	2·535	2·532	2·529	2·525	2·522	1·0
1·1	2·538	2·535	2·532	2·529	2·525	2·522	2·519	2·516	2·512	2·509	2·506	2·503	2·499	1·1
1·2	2·516	2·512	2·509	2·506	2·503	2·499	2·496	2·493	2·490	2·486	2·483	2·480	2·477	1·2
1·3	2·493	2·490	2·486	2·483	2·480	2·477	2·473	2·470	2·467	2·464	2·460	2·457	2·454	1·3
1·4	2·470	2·467	2·464	2·460	2·457	2·454	2·451	2·447	2·444	2·441	2·438	2·434	2·431	1·4
1·5	2·447	2·444	2·441	2·438	2·434	2·431	2·428	2·425	2·421	2·418	2·415	2·412	2·408	1·5
1·6	2·425	2·421	2·418	2·415	2·412	2·408	2·405	2·402	2·399	2·395	2·392	2·389	2·386	1·6
1·7	2·402	2·399	2·395	2·392	2·389	2·386	2·382	2·379	2·376	2·373	2·369	2·366	2·363	1·7
1·8	2·379	2·376	2·373	2·369	2·366	2·363	2·360	2·356	2·353	2·350	2·347	2·343	2·340	1·8
1·9	2·356	2·353	2·350	2·347	2·343	2·340	2·337	2·334	2·330	2·327	2·324	2·321	2·317	1·9
2·0	2·334	2·330	2·327	2·324	2·321	2·317	2·314	2·311	2·308	2·304	2·301	2·298	2·295	2·0
2·1	2·311	2·308	2·304	2·301	2·298	2·295	2·291	2·288	2·285	2·282	2·278	2·275	2·272	2·1
2·2	2·288	2·285	2·282	2·278	2·275	2·272	2·269	2·265	2·262	2·259	2·256	2·252	2·249	2·2
2·3	2·265	2·262	2·259	2·256	2·252	2·249	2·246	2·243	2·239	2·236	2·233	2·230	2·226	2·3
2·4	2·243	2·239	2·236	2·233	2·230	2·226	2·223	2·220	2·217	2·213	2·210	2·207	2·204	2·4

Gallons Oil Used per 1000 C.Ft. C.W.G.	P.Ct. Inerts in Carburetted Water Gas.													Gallons Oil Used per 1000 C.Ft. C.W.G.
	15·5	15·6	15·7	15·8	15·9	16·0	16·1	16·2	16·3	16·4	16·5	16·6	16·7	
0·0	2·746	2·743	2·740	2·737	2·733	2·730	2·727	2·724	2·720	2·717	2·714	2·711	2·707	0·0
0·1	2·724	2·720	2·717	2·714	2·711	2·707	2·704	2·701	2·698	2·694	2·691	2·688	2·685	0·1
0·2	2·701	2·698	2·694	2·691	2·688	2·685	2·681	2·678	2·675	2·672	2·668	2·665	2·662	0·2
0·3	2·678	2·675	2·672	2·668	2·665	2·662	2·659	2·655	2·652	2·649	2·646	2·642	2·639	0·3
0·4	2·655	2·652	2·649	2·646	2·642	2·639	2·636	2·633	2·629	2·626	2·623	2·620	2·616	0·4
0·5	2·633	2·629	2·626	2·623	2·620	2·616	2·613	2·610	2·607	2·603	2·600	2·597	2·594	0·5
0·6	2·610	2·607	2·603	2·600	2·597	2·594	2·590	2·587	2·584	2·581	2·577	2·574	2·571	0·6
0·7	2·587	2·584	2·581	2·577	2·574	2·571	2·568	2·564	2·561	2·558	2·555	2·551	2·548	0·7
0·8	2·564	2·561	2·558	2·555	2·551	2·548	2·545	2·542	2·538	2·535	2·532	2·529	2·525	0·8
0·9	2·542	2·538	2·535	2·532	2·529	2·525	2·522	2·519	2·516	2·512	2·509	2·506	2·503	0·9
1·0	2·519	2·516	2·512	2·509	2·506	2·503	2·499	2·496	2·493	2·490	2·486	2·483	2·480	1·0
1·1	2·496	2·493	2·490	2·486	2·483	2·480	2·477	2·473	2·470	2·467	2·464	2·460	2·457	1·1
1·2	2·473	2·470	2·467	2·464	2·460	2·457	2·454	2·451	2·447	2·444	2·441	2·438	2·434	1·2
1·3	2·451	2·447	2·444	2·441	2·438	2·434	2·431	2·428	2·425	2·421	2·418	2·415	2·412	1·3
1·4	2·428	2·425	2·421	2·418	2·415	2·412	2·408	2·405	2·402	2·399	2·395	2·392	2·389	1·4
1·5	2·405	2·402	2·399	2·395	2·392	2·389	2·386	2·382	2·379	2·376	2·373	2·369	2·366	1·5
1·6	2·382	2·379	2·376	2·373	2·369	2·366	2·363	2·360	2·356	2·353	2·350	2·347	2·343	1·6
1·7	2·360	2·356	2·353	2·350	2·347	2·343	2·340	2·337	2·334	2·330	2·327	2·324	2·321	1·7
1·8	2·337	2·334	2·330	2·327	2·324	2·321	2·317	2·314	2·311	2·308	2·304	2·301	2·298	1·8
1·9	2·314	2·311	2·308	2·304	2·301	2·298	2·295	2·291	2·288	2·285	2·282	2·278	2·275	1·9
2·0	2·291	2·288	2·285	2·282	2·278	2·275	2·272	2·269	2·265	2·262	2·259	2·256	2·252	2·0
2·1	2·269	2·265	2·262	2·259	2·256	2·252	2·249	2·246	2·243	2·239	2·236	2·233	2·230	2·1
2·2	2·246	2·243	2·239	2·236	2·233	2·230	2·226	2·223	2·220	2·217	2·213	2·210	2·207	2·2
2·3	2·223	2·220	2·217	2·213	2·210	2·207	2·204	2·200	2·197	2·194	2·191	2·187	2·184	2·3
2·4	2·200	2·197	2·194	2·191	2·187	2·184	2·181	2·178	2·174	2·171	2·168	2·165	2·161	2·4

APPENDIX 2 (*continued*).

Gallons Oil Used per 1000 C.Ft. C.W.G.	P.Ct. Inerts in Carburetted Water Gas.													Gallons Oil Used per 1000 C.Ft. C.W.G.
	16·8	16·9	17·0	17·1	17·2	17·3	17·4	17·5	17·6	17·7	17·8	17·9	18·0	
0·0	2·704	2·701	2·698	2·694	2·691	2·688	2·685	2·681	2·678	2·675	2·672	2·668	2·665	0·0
0·1	2·681	2·678	2·675	2·672	2·668	2·665	2·662	2·659	2·655	2·652	2·649	2·646	2·642	0·1
0·2	2·659	2·655	2·652	2·649	2·646	2·642	2·639	2·636	2·633	2·629	2·626	2·623	2·620	0·2
0·3	2·636	2·633	2·629	2·626	2·623	2·620	2·616	2·613	2·610	2·607	2·603	2·600	2·597	0·3
0·4	2·613	2·610	2·607	2·603	2·600	2·597	2·594	2·590	2·587	2·584	2·581	2·577	2·574	0·4
0·5	2·590	2·587	2·584	2·581	2·577	2·574	2·571	2·568	2·564	2·561	2·558	2·555	2·551	0·5
0·6	2·568	2·564	2·561	2·558	2·555	2·551	2·548	2·545	2·542	2·538	2·535	2·532	2·529	0·6
0·7	2·545	2·542	2·538	2·535	2·532	2·529	2·525	2·522	2·519	2·516	2·512	2·509	2·506	0·7
0·8	2·522	2·519	2·516	2·512	2·509	2·506	2·503	2·499	2·496	2·493	2·490	2·486	2·483	0·8
0·9	2·499	2·496	2·493	2·490	2·486	2·483	2·480	2·477	2·473	2·470	2·467	2·464	2·460	0·9
1·0	2·477	2·473	2·470	2·467	2·464	2·460	2·457	2·454	2·451	2·447	2·444	2·441	2·438	1·0
1·1	2·454	2·451	2·447	2·444	2·441	2·438	2·434	2·431	2·428	2·425	2·421	2·418	2·415	1·1
1·2	2·431	2·428	2·425	2·421	2·418	2·415	2·412	2·408	2·405	2·402	2·399	2·395	2·392	1·2
1·3	2·408	2·405	2·402	2·399	2·395	2·392	2·389	2·386	2·382	2·379	2·376	2·373	2·369	1·3
1·4	2·386	2·382	2·379	2·376	2·373	2·369	2·366	2·363	2·360	2·356	2·353	2·350	2·347	1·4
1·5	2·363	2·360	2·356	2·353	2·350	2·347	2·343	2·340	2·337	2·334	2·330	2·327	2·324	1·5
1·6	2·340	2·337	2·334	2·330	2·327	2·324	2·321	2·317	2·314	2·311	2·308	2·304	2·301	1·6
1·7	2·317	2·314	2·311	2·308	2·304	2·301	2·298	2·295	2·291	2·288	2·285	2·282	2·278	1·7
1·8	2·295	2·291	2·288	2·285	2·282	2·278	2·275	2·272	2·269	2·265	2·262	2·259	2·256	1·8
1·9	2·272	2·269	2·265	2·262	2·259	2·256	2·252	2·249	2·246	2·243	2·239	2·236	2·233	1·9
2·0	2·249	2·246	2·243	2·239	2·236	2·233	2·230	2·226	2·223	2·220	2·217	2·213	2·210	2·0
2·1	2·226	2·223	2·220	2·217	2·213	2·210	2·207	2·204	2·200	2·197	2·194	2·191	2·187	2·1
2·2	2·204	2·200	2·197	2·194	2·191	2·187	2·184	2·181	2·178	2·174	2·171	2·168	2·165	2·2
2·3	2·181	2·178	2·174	2·171	2·168	2·165	2·161	2·158	2·155	2·152	2·148	2·145	2·142	2·3
2·4	2·158	2·155	2·152	2·148	2·145	2·142	2·139	2·135	2·132	2·129	2·126	2·122	2·119	2·4

Discussion.

The PRESIDENT: I should like in the first place to congratulate Mr. Hollings on this paper, which has set a new standard and a new investigation for us in regard to carbonization and water gas practice. My friend Mr. Hardie has conferred another kindness upon me by letting me have this paper, and I should like to express from the Chair how deeply I appreciate what he has done in connection with this meeting. Coming to the paper itself, I have never yet been converted from the 22-in. by 16-in. retort, more especially for Welsh coal; and what I see in Mr. Hollings' paper rather convinces me that I am right in my view that a 22-in. by 16-in. retort, with a 9-cwt. charge, and 8 hours' duration, gives the best results. A point that impressed me was that relating to the carbon content of the tar. Mr. Hollings stresses that it is an important index as to the coal carbonization. That might help you engineers who are using Yorkshire coal, but those of us who have to use Welsh coal know that the carbon content is one of the greatest factors we have to contend with. In fact, years ago we had to examine this important point because we had so much trouble when we tried to increase the temperature of carbonization. Another important point Mr. Hollings has raised is that of the coal gas leakage through the retorts. I do not think any of us realize how many therms are lost through the wall leakage of the retorts; and if there is one point in this paper which is most calculated to do good it is that of leakage of gas through the retorts. I never realized that it could develop to the extent that Mr. Hollings has mentioned, and it goes to show how necessary is the scientific control of carbonizing. Surely Mr. Hollings' paper is an indication of this? With regard to the slide-rule mentioned by Mr. Hollings, I hope this will be available to the industry in a very short time.

Mr. HOLLINGS: There is no reason why it should not be.

The PRESIDENT: I think it ought to be in all our laboratories. I commend this paper to the members.

Prof. J. W. COBB: I should like to mention that Mr. Hollings was my first research student at Leeds. [Applause.] This is not his first appearance on the platform of this Institution, because he came forward in 1913 and 1914 with contributions on thermal phenomena in carbonizing, and was then speaking as Gas Research Fellow. He now speaks as one holding a very responsible position in the leading organization in the industry, and I think that is a very good omen for the future of scientifically-trained men in this industry and in the ranks of the Institution. The subject matter of his paper is of special interest to those of us who are concerned with the scientific training of young men entering the industry, because it serves to define by example what the position of the chemist ought to be, and what is the nature of the service that he can render to the industry. The very useful part of the paper which relates to ammonia is a contribution which will be of the greatest value to the Effluents Research Committee and to all of those who have any concern with the problems of that Committee. It shows how much can be done, without radical changes in plant, but by a proper consideration of the way in which the plant functions and of the most efficient manner in which existing plant can be put to good service.

Mr. L. H. SENSICLE (Newcastle-on-Tyne): With regard to Mr. Hollings' point as to the distribution of water gas and coal gas in vertical retorts when steamed, I think that caution should be used in applying his method, because it might not be applicable to coals which are contaminated by shaley matter from the seam. Possibly Mr. Hollings is dealing with coals which are clean, or very nearly clean. The stone that is associated with the seam contains matters which yield gas, and according to some experiments I have had carried out recently, there is a rather remarkable contribution from that stone. We picked out some shale from a seam from which we were receiving coal, and found that we were getting about 20 therms of gas per ton from that shale. We thought that possibly the shale might be contaminated with coal, and we applied to the owners of a local coal-cleaning plant and obtained some clean shale separated by means of a dry cleaner. The shale contained ash to the extent of 78 p.ct., volatiles 14·5 p.ct., and fixed carbon 5·5 p.ct., and it gave a thermal yield of 17·67 therms per ton, a gas of a calorific value of 372 B.Th.U., and a yield of 4750 c.ft. per ton at a temperature of 1100° C. The gas analysis indicates that there is a mixture of hydrocarbons derived from possibly bituminous matter, which has been taken up by the shale from the neighbouring seam; and there is also evidence of water gas production derived probably from the water constituent of the mineral matter reacting with the carbon. The carbon monoxide content of the gas was 26·3 p.ct., the hydrogen 38·8 p.ct., and the methane 9·9 p.ct. The gas was obtained from a number of carbonizations, and the results are really an average. Possibly the question of the contribution of the stone to the gas yield needs to be considered before we can apply such a method as Mr. Hollings delineates for differentiating between the yield from the pure coal and the yield from steaming. With regard to the leakage of gas from the vertical retorts into the flues, it is interesting that Mr. Hollings has proved in two ways that this leakage takes place; and the way in which he proves it, by results on a waste-heat boiler, brings out a fact which has been stated several times, that the figures which have been published for steam production in waste-heat boilers are added to by leakage from the retort, and that the high figures obtained are not always attributable alone to the efficiency of the waste-heat plant. I think Mr. Hollings' paper is a most valuable contribution to the literature on the subject.

Dr. A. PARKER (Leeds): I gather that the methods given in the paper are purely examples, and that they could not be applied at every works absolutely in the form as given here. In any case, the skill of the highly trained chemist is required to apply them; but they do show what can be done. Mr. Hollings has rendered an extremely useful service by emphasizing how much gas is lost by leakage through the retort walls; and it is really surprising how many times a point of that kind has to be brought to our attention before it is generally appreciated. Mr. Hollings has referred to the work of the Gas Investigation Committee as described in the Twelfth Report, published in 1924; he acknowledges that work, and says definitely that he has determined leakages by using the waste-heat boiler results and calculations on the principles adopted in that Twelfth Report. Again, the leakages through retort walls were expressed in pounds of carbon per hour on waste-heat boiler methods. The work was referred to in the William Young Memorial Lecture in 1924, and there was a paper by Mr. T. F. E. Rhead at the carbonization conference in Birmingham this year on the same subject, so that this matter is gradually being brought to the front. Of course, there is some difficulty. One cannot carry out tests on a particular installation and say that this installation is losing 10 p.ct. of its thermal yield, without the risk of giving the impression that this particular installation is in a bad condition. That impression may be a wrong one, because I believe there is a considerable leakage from the average installation of retorts with refractory materials; and very careful steps will have to be taken to avoid that leakage. With regard to the future, I often wonder whether in (say) twenty or thirty years time, we may not be using alloy retorts—not necessarily alloy steels, but

alloy retorts of some kind—probably of smaller section, but perfectly gastight, even at the expense of having to reduce the carbonizing temperature slightly.

Mr. T. F. E. RHEAD (Birmingham): I should like to say how thoroughly I have enjoyed Mr. Hollings' paper. It is a real intellectual treat, and it augurs well for the future of chemistry in the gas industry. Naturally, many of the points raised in such a comprehensive paper have received attention in other works, and I should like to comment on some with which I have had experience. In discussing the "profitable degree of cracking," mentioned by Mr. Hollings, I find it useful to consider coal gas as being made up largely of a 320 calorific value gas (hydrogen and carbon monoxide) enriched by such gases as methane, ethylene, hydrocarbon vapours, &c. The basic gas can be made in almost unlimited quantities by the steam-coke reaction, and the chemist's objective is to determine under what condition each or all of the enrichers can be produced in maximum quantities. "One-stage" carbonization as at present practised may not be the final solution; some form of multiple-stage carbonization may come. The most powerful enrichers are the light spirits, and I agree that their determination by gas analysis methods is entirely unsatisfactory. At Birmingham they are at present determined by oil absorption in a special scrubber* capable of scrubbing up to 10 c.ft. of gas per hour. Special oil is made by distilling gas oil to 250° C. (thermometer in vapour—which is important) and submitting the residue to prolonged steam distillation at 150° C. (thermometer in liquid). After use, the absorbed spirits are obtained from the oil by steam distillation. (The use of charcoal as an adsorbent might lead to polymerization of some of the highly unsaturated bodies in the spirit.)

From the different analyses and calorific values of the spirits and stripped gas, together with tar analyses, &c., a considerable amount of information is being obtained as to the causes for the different efficiencies of the various works. We have also obtained some important information concerning the spirits given by different coals on both horizontals and verticals on our coal test works. It is important to note that satisfactory agreement is obtained between the calculated and determined calorific values of the stripped gas.

I should like to have seen the distillations of the unwashed spirits as well as the washed, to compare with the Birmingham results. The complete study of these spirits is a most important matter, and, like Mr. Hollings, I hope to put forward more complete information at a later date. I am not quite clear as to the meaning of the quantity of phenol in tar acids, given in Table 5. Tar acids in horizontal *versus* vertical tars show much wider differences than are indicated by the phenol equivalent.

As regards waste gas analyses, since Dr. Parker introduced his method in 1924 as a possible means of calculating retort leakage, we have explored it in many directions, and, under properly defined conditions, have found it very useful. I would strongly emphasize Mr. Hollings' words, "provided that the gas has been carefully sampled and accurately analyzed." It would not be fair to expect such work to be carried out by the average routine chemist; the method demands the services of a skilled chemist. A difference of 0·1 p.ct. between the actual CO_2 content of the waste gas (suitably corrected for air, &c.) and that theoretically possible from the producer gas means something of the order of 1 therm leakage of coal gas. (The method will not indicate water gas leakage.) The method is subject to an experimental error of about ± 10 p.ct. on the thermal leakage indicated. Either long continuous samples over mercury or an average of many spot samples are necessary to average-out fluctuations in composition—clinkering times to be avoided. Samples from the flues of individual retorts show wide divergencies, which might be due to leakage or varying quantities of waste gases in the flues.

We have compared the results of this method with observations of the retorts at scurfing times. By putting excess producer gas into the flues under slight pressure, holes or cracks in the retorts are indicated by tongues of flame projecting into the retort. The only way of being certain that one has put slight pressure on the combustion flues is to use a delicate gauge reading to 1/100-in. water gauge. In Birmingham we have tested leakage by sealing the retort at top and bottom and pumping in cooled waste gases. By this method we have tested new retorts and the same retorts after they have been working, before and after scurfing. (The new retorts were tested using air.) The typical figures in the table following indicate the order of the leakage found at the pressure shown.

The same retort tested after a few years of work, when gas-making results indicated severe leakage, gave a leakage of waste gas pumped in equal to 5000 c.ft. per hour with 0·1-in. pressure in the bottom of the retort. The value of a certain amount of scurf on the retorts is well indicated, and its action in reducing leakage is reassuring.

* J.S.C.I., p. 768, 1917.

Pressure in Ironwork at Bottom of Retort. Above Atmospheric (Inches, Water).	Differential Pressure Between Flues and Retort at Bottom (Approx.).	C.Ft. per Hour Leaking from Retort.		
		A. Brand New Retort Without Scurf. Hot.	B. New Retort, With Scurf. Hot.	C. Retort After Scurfing. Hot.
0·01	0·25	..	80	830
0·1	0·35	1090	210	1200
0·2	0·45	1360	330	1690*
0·3	0·55	1620	440	..
0·4	0·65	1880	530	..
0·5	0·75	2160	640	..

* By exterpolation.

The above figures indicate the tremendous importance of maintaining correct conditions of pressure in the retort—an extremely difficult matter with swelling, sticky coals. Further, it is important to watch the leakage from top ironwork, either of crude gas from under the joint between the casting and the retort, or of air into the retort and ironwork.

I have to thank Messrs. Myhill, A.I.C., and Shorrock, M.Sc., for helping with this work. It is hoped to send a complete account of it to the Technical Press at some future date.

Mr. JNO. P. LEATHER (Letchworth): I should like to add my appreciation of this paper, and to refer to the last portion of it, dealing with the question of gas oil. Surely the diagram in fig. 10, with regard to the cracking of oils, might be very much altered, for when putting larger quantities of oil through the apparatus the temperature of cracking was varied to obtain better cracking, so that I do not see in what way that diagram is of very great importance. On the last page of the paper the author refers to work which has shown a certain connection between the quality of an oil for gas-making purposes and the constitution. It may have been shown by recent work, but it is exactly what I brought forward in a paper I read before the Institution about twenty years ago. It is not at all recent work which has shown the connection between the amount of open-chain hydrocarbons and the power of a gas-works to enrich the gas; and recent work which I have had to do on gas oils shows that this question is one of importance. The gas oils on the market to-day are considerably different from those available twenty years ago, and it is advisable that there should be proper testing of gas oils if a gas engineer is to know what he is getting when buying gas oil. Only this year I have had to do some more work on this matter, the results of which confirm what I stated before this Institution, and before the Society of Public Analysts and the Society of Chemical Industry, twenty years ago.

(At this point, owing to the shortness of time, the President asked that further contributions to the discussion be submitted in writing.)

Mr. HOLLINGS, replying to the discussion, said: I am very much indebted to you for the kind reception you have given this paper. With regard to the calculations in connection with the question of gas leakage, I hope the paper makes it perfectly clear that what I have attempted to do is to translate the work of Dr. Parker and others at Leeds; and I hoped perhaps to express one or two of the results in a form in which they may be more readily appreciated. In going over some of these calculations we were very much impressed by the bearing of this matter upon horizontal retort practice, and it was this which led me to the conclusion that it was worth while re-writing some of the old matter in this particular form. Prof. Cobb has reminded you of my past, or at least of a part of it. [Laughter.] May I say that of that part—namely, my early association with him—I am indeed very proud. I am obliged to Mr. Sensicle for his remarks, because he will appreciate that my calculations are intended to be approximate only, and particularly illustrative of a method, and not in any sense as representing an exhaustive treatment of the subject. Mr. Rhead asks if I can give information as to distillations of unwashed spirits. We have certain such distillation curves, but I think these should be considered in further detail, and perhaps they ought to form the subject of some separate communication after further investigation. I regret that the result given for tar acids is rather misleading. It should have been explained that these were tar acids recovered by steam distillation. He points out the limitations of these calculations respecting gas leakage, and I think it was Mr. Rhead who also emphasized the need for skilled assistance in this matter. I fully agree with him. In a paper of this type it is difficult to make a proper acknowledgment of all previous work, but I fully recognize the pioneer work of Mr. Leather in connection with the analysis of gas oil. We have not overlooked that. Indeed, I am hoping, and I think I said so in my paper, to have an early opportunity of publishing a more detailed contribution on this particular matter, and, of course, in that contribution I should make detailed reference to and comparison, with the work of Mr. Leather.

GAS SUPPLY EAST OF SUEZ.

By S. BARKER JOHNSON, F.C.S., M.I.Mech.E., M.I.Chem.E., Engineer and Manager of the Colombo Gas and Water Company, Ltd., Colombo.

The absence from the Institution's Transactions of any paper or casual remarks relating to gas-works practice or gas distribution in an Eastern city can be explained in two ways: First, the number of British-owned gas undertakings operating out East is very few; and secondly, it is perhaps thought that gas supply out East has little in common with the West.

Taking the first reason, there are on the main East and Far East route only six British undertakings east of Suez. They are—in the order of travel—Bombay, Colombo, Calcutta, Singapore, Hongkong, and Shanghai.

The second reason given is a conclusion generally arrived at by the average gas man in England; but in this paper the writer hopes to show that such an opinion is quite an erroneous one, for an Eastern gas engineer, apart from having quite a lot in common with his confrères in Britain, can, in a number of cases, by dint of being thrown on his own resources from time to time, set and maintain on general lines a higher standard of gas-works practice than is sometimes met with at home.

With these preliminaries he would like to bring to the notice of the members a few points arising in the manufacture and distribution of gas at Colombo, in the island of Ceylon.

The gas undertaking at Colombo, of which he has had the honour of being the Engineer and General Manager since 1919, is owned and operated by an English Company—the Colombo Gas and Water Company, Ltd.—whose head office is in Gresham House, London. It was formed towards the close of 1868, and Colombo was first lighted by gas on Aug. 10, 1872—nearly 56 years ago.

The author, before going further, wishes to give a few details as to the climate and general lie of Colombo. The island itself lies between 6° and 9° north of the equator, and in a longitude of 80° and 82°. The capital of this Crown Colony, Colombo, which is the recognized centre of business, political, and social life in the island, is practically 7° off the equator (many a time we think it is actually *on* the equator), is some 7000 miles from London, and has a population of 260,000, of which about 2000 only are Europeans.

The climate of Colombo can, without elaboration, be put down as damp, resembling an English greenhouse. The average mean temperature ranges from 79° to 82° Fahr., and rises to about 94° before the monsoon periods; the rainfall is approximately 90 in. in the year. Humidity percentage rises to as high as 90 or 95, and one invariably changes one's clothes to the skin four or five times a day.

The Port itself has been described as the Charing Cross of the East—a great port of call and a central meeting place for passengers to and from the East, Australia, and Africa. Colombo has also been termed the dustiest city in the East.

The type of material one has to deal with in respect of workmen is very varied. Singhalese, Burghers, Tamils, Moormen, Malays, and Hindus form the bulk of the labouring and artisan class in the island. Generally speaking, the standard of education found among those offering themselves for employment in the office is low, and, of course, lower with workmen and fitters; and as a rule it may be said that we have to teach every one of our men his trade.

So much for Colombo itself. The city has been greatly improved within recent years; and while life in the Tropics is undoubtedly more risky than at home, the writer considers Colombo to be the best and healthiest city to live in out East.

For purposes of easy reference, he gives below a résumé of the main subject headings upon which he will enlarge in the course of this paper:

1. Disadvantages of gas in the Tropics.
2. Carbonizing methods.
3. Engineering extensions.
4. Fittings department.
5. Meter department.
6. Public lighting.
7. Advertising.
8. Keeping abreast of the times.
9. Advice to those going abroad.

1. Disadvantages of Gas in the Tropics.

The chief difficulty under which gas labours in the Tropics is clearly on account of its "heat." An incandescent burner or fitting generates a great deal of heat, which in cold climates is a distinct advantage, apart from the ventilating effect which it produces. Out East, bungalows are built with practically no doors or windows; everything is more or less open, and the ventilating question does not arise.

Most of the residents in the better-class bungalows require electric fans in all rooms, and certainly no native landlord will go to the expense of fitting in electric wiring for fans alone, and gas piping for lights. He puts in electric light and fans, and the installation finishes at that.

In Colombo there is, and has been for years, a strong Electric Company; this year (1928) the Government has taken over the electric supply of the city, and is presently engaged on a hydro-electric project for the island. Electric current is sold at 7d. per unit for lighting, and 2d. for power.

Another disadvantage is to be found in the insect and dust nuisance. The bungalows and rooms being so much open, there is every opportunity for insects to infest the burners and clog up the gas and air regulating devices. This, together with dust during the dry season, works havoc not only with street fitments, but with indoor lamps; and close attention is required. In some quarters we find the arc lamp globes on the street lamps to be nearly one-third filled with flies in a night, so necessitating daily attention and cleaning; and what applies to street lamps applies equally to bungalow lights. Some parts of the town are, of course, much better than others.

Undoubtedly electricity has a strong advantage over gas in respect of the switch device for turning lamps on and off. The ordinary pneumatic switches such as we sell to customers are, in the Tropics, really a source of constant trouble; they are always sticking, and apart from this the house servants ("boys" as they are called) seem to be able to turn an electric switch on and off, but when it comes to a gas switch or a by-pass attachment, there appears to be no attempt to turn it off temporarily in the same manner. Some member may say that this is a good thing, tending to boost up the output!

While recording these disadvantages, it must be understood that, being taxed with such, the gas engineer needs to be very much keener in his attention in keeping up an efficient supply.

2. Carbonizing Methods.

The retort house plant at Colombo now consists of ten beds of through retorts—five beds of sixes and five beds of eights, making a total of 140 mouthpieces. In 1924 the house was completely remodelled and fitted with a Guest-Gibbons stoking machine and coal handling plant. The retorts are 21 in. by 15 in. and 22 in. by 16 in. D shaped, 20 ft. long.

The plant consists of two sets of condensers, four Livesey washers, three tower scrubbers, two "P. & A."

tar extractors, three exhauster sets, six purifiers, two station meters, three holders on works and one on district, six station governors, a tar dehydrating plant, an electric generating set for retort house machinery, stove and geyser workshops, and carpentry, blacksmith, and machine shops. When the author joined the Company, only about one-third of the foregoing plant existed; the remainder has been added within very recent years.

The retorts were formerly "singles;" the make of gas—using Indian coal—averaged 10,000 c.ft. per ton, and the annual make the year prior to his taking over management was 85 millions.

Last year (1927) the average make was 19,800 c.ft. per ton of 450 B.Th.U. gas, with native labour, the same class of Indian coal, and with no steaming, and the total gas made was 271,265,000 c.ft. The make per mouthpiece has also increased from an average of 5000 c.ft. in 1914 to 12,000 c.ft. now. Approximately 14 cwt. of coal are put into the 22 in. by 16 in. retorts, and 12 cwt. in the smaller retorts. In charging, only one retort is opened at a time. The coke is pushed out, and after the second charge of coal (it takes four pushes of the machine to fill a retort) is put in, the mouthpiece at the discharging side is closed. As soon as the last charge of coal has entered, the retort is closed and the next retort is opened.

The author thinks there are few English works returning with ordinary horizontals such a high yield of gas—over 89 therms per ton—and the Indian coal is not to be regarded as a particularly rich coal. The average analysis is as follows:

Moisture	2·00 p.ct.
Volatile carbon	29·73 ,,
Fixed carbon	56·52 ,,
Ash	11·75 ,,
	100·00
Coke	66·27 p.ct.
Sulphur	0·10 ,,
Nitrogen	1·99 ,,
Carbon	72·80 ,,
Hydrogen	5·80 ,,

It will be noticed the sulphur content is practically negligible.

It is a true saying that dividends are made in the retort house. If the carbonizing plant is kept well tuned-up, it is surprising how constantly good results can be attained. We aim to keep up a good average heat—not an intense one. We find that, provided flues and fires are cleaned regularly, if the benches are worked with as near as possible a constant draught on the main flue, there is little to go wrong. The flue dampers (four to each bed) once set need little adjustment. If a bench drops in heat it is, at Colombo, a sure sign that either the flues are dusty, or the furnace has not been correctly fed with hot coke.

As we get a fairly constant temperature all the year round, we find the main chimney draught does not alter materially. In the hot weather when the air outside the stack is almost as hot as that inside, it must be confessed that it is very difficult to maintain a good pull and heat. Our chimney shafts are built higher than is the case in England, for this reason. The beds are worked to a slight pressure at the soffet. We practise 12-hour full charges, the furnaces are fed four times a day, generally at 8 a.m., 2 p.m., 8 p.m., and 2 a.m., and clinkered twice in the 24 hours (about 7 a.m. and 7 p.m.), and pricked twice during the 24 hours.

Ordinary hydraulics, 2¾ in. seals, are in use with tar towers, and a vacuum of roughly 2½ in. is generally maintained on the house. We have no retort house governor. The foul main travels round the inside of the building, and the condensers, three washers and two tower scrubbers, are all on the inlet side of the exhauster. There is a vacuum of some 12 to 14 in. on the inlet, to overcome the various seals. Our total back-pressure on the outlet side varies from 18 to 24 in. The temperature of the gas at the exhauster, even after all this cooling and scrubbing, is sometimes as high as 80°, and so we have further cooling plant (a tower scrubber, two "P. & A." extractors, and one washer) on the outlet side. In the Tropics far greater condensing area is of course required than in colder climates.

We have prided ourselves for some years past on returning an extraordinarily low fuel account. It is a common average on English works, the writer thinks, to find the coke used in the furnaces to be 20 p.ct. on the coke made, or 14 p.ct. on the coal carbonized. Our results at Colombo since 1919 have been as follows:

Year.	Coke Used.	
	P.Ct. of Coal.	P.Ct. of Coke.
1919	9·8	18·89
1920	9·59	17·49
1921	8·77	16·09
1922	8·36	17·14
1923	6·72	12·93
1924	6·29	11·24
1925	7·42	13·16
1926	6·22	11·28
1927	5·76	9·58

The coke wheeled out of the retort house last year (1927) was 10·88 cwt. per ton of coal carbonized. The coke made per ton was 12·03 cwt.

The author thinks it will be said that these fuel figures are remarkable. During the past year (1927):

13,700 tons coal were carbonized
8,240 ,, coke ,, made
7,477 ,, ,, ,, sold
790 ,, ,, ,, used in the furnaces

Some gas engineers who have passed through Colombo and have been shown these results say that they are incredible; yet we seldom, if ever, have a ton of coke in stock, so that these fuel statistics are not liable to be fictitious on account of stocks.

The low consumption on the furnace helps us to no small degree in our residual sales; and in 1926 we were in the almost unique position of recording a residuals sale of just over 100 p.ct. on the cost of coals carbonized. Last year our figure was 92 p.ct. In other words, the price we obtain for our coke and tar practically pays for all the coal we use (tar made per ton averaged last year 10·1 gallons).

Presumably most of the members will ask how we manage to effect such a fuel economy. This is a difficult question to answer; there are so many factors which go to make up retort house efficiency—correct and regular feeding of furnaces with hot coke, keeping the producer caps tight, continual patching up of cracks in settings, &c. Careful attention and a keen eye are indispensable to carbonizing results.

Our retort house costs, by which is meant retort house, engine and boiler room, stokers, foremen, mechanics, and coolies' wages pure and simple—*i.e.*, the actual wages paid to make the gas—are also low, and have shown a tremendous drop since the introduction of mechanical devices, as will be seen on reference to the following figures:

Year.	
1922	9·77 cents per 1000 c.ft. made
1923	9·48 ,, ,, ,, ,,
1924	8·90 ,, ,, ,, ,,
1925	5·99 ,, ,, ,, ,,
1926	5·18 ,, ,, ,, ,,
1927	3·95 ,, ,, ,, ,,

It may be taken that 5½ cents (present exchange) equal 1d. It is questionable whether many gas undertakings can show such a low working cost as that to which we are working to-day at Colombo.

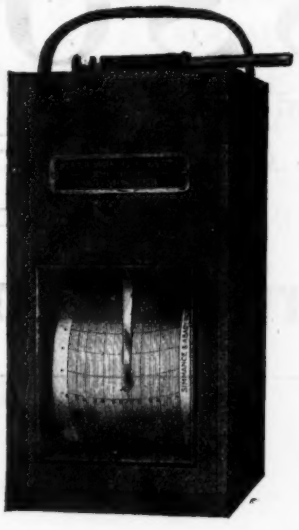
Stokers' pay is 2s. 2d. per day of 12 hours, and cooly labour is 1s. 2d. per day of 9 hours.

Clinker from the furnaces is picked through by two cooly women (getting 8d. a day), and quite an appreciable quantity of dirty coke—which we term second quality coke—is obtained. This coke is sometimes put in the furnaces when a bed is not being worked to its full capacity; any accumulated stock is sold. Practically no breeze is made.

We get very little retort carbon (the retorts only need scurfing twice a year), and stopped pipes are practically an unknown occurrence. We are very particular in making the native stokers augur every pipe whether it is wanted or not, when each retort is opened.

3. Engineering Extensions.

With regard to the annual make of gas, the figures given



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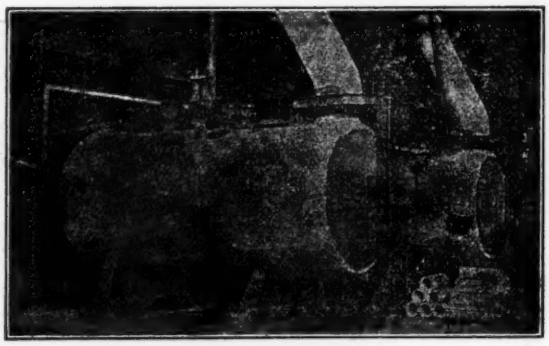

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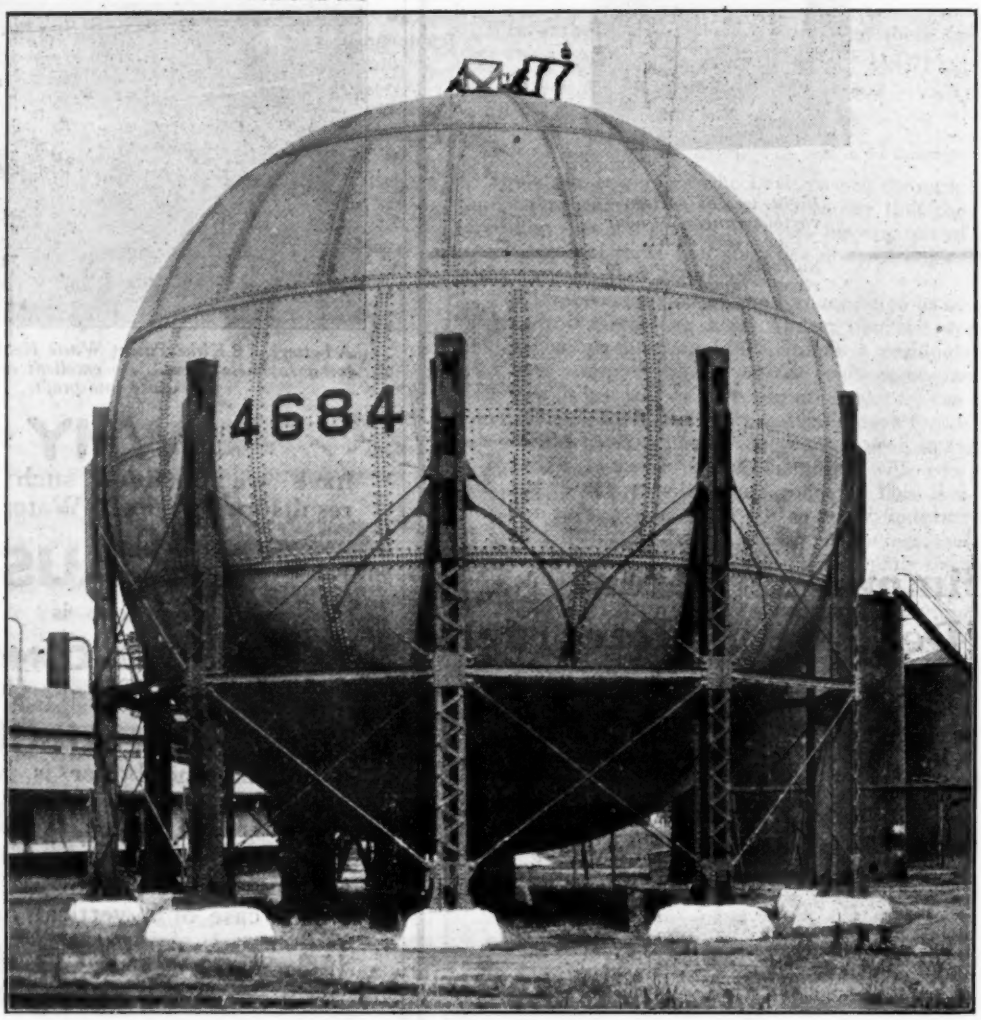

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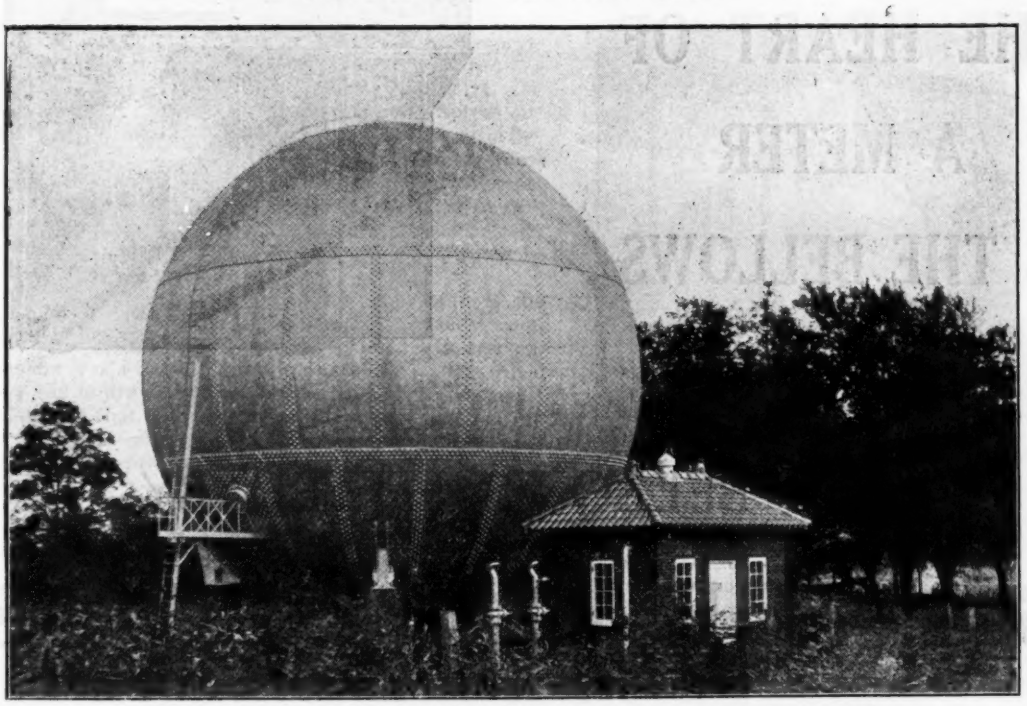

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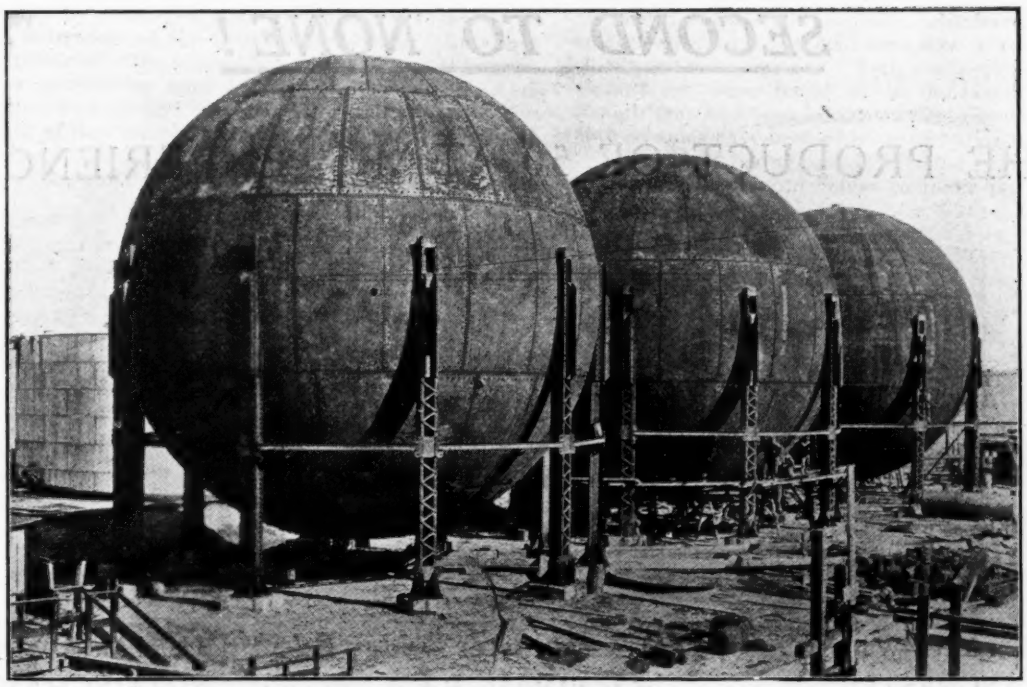

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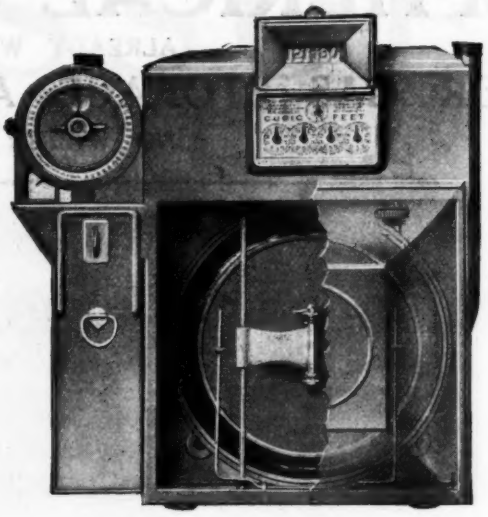

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previously indicate an increase of practically 220 p.ct. in nine years.

This phenomenal increase has not come about of its own accord; neither is it due (to any appreciable extent) to opening-up new suburbs. Colombo is not like an English seaside resort where a big influx of visitors occurs year by year during the holiday seasons, with the consequent boom in gas sales in boarding houses, &c., for a space of three or four months. The increase in output and business has been brought about by dint of perseverance in advertising, and the popularization of gas. The Colombo limits are somewhat arbitrary, and it can be said that the town has not grown to any marked degree during the past decade.

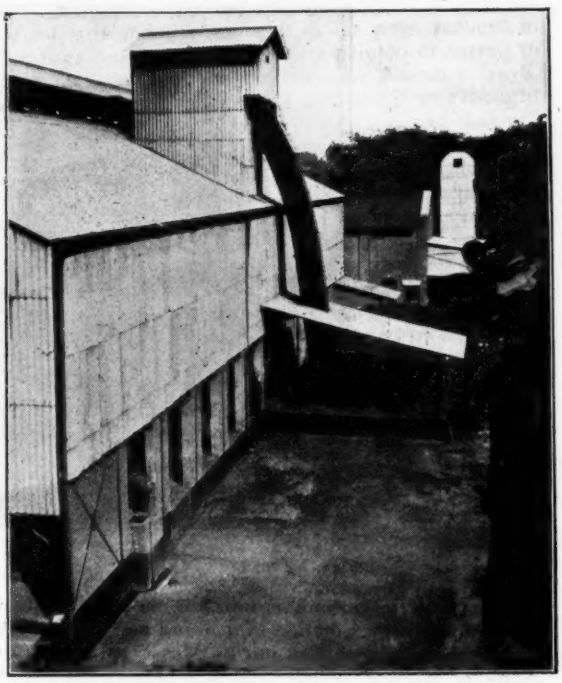
In 1918 the gas output showed a decrease of 21 p.ct. on the year 1917. In 1919 this decrease was converted into an increase of 16 p.ct. over 1918, and in 1920 a further increase over 1919 of 21 p.ct. was recorded. And so these increases developed. (Last year we recorded an increase of 23 p.ct. over 1926.) It accordingly became very evident shortly after assuming management that sooner or later extensions to manufacturing and storage plant would be necessary.

In 1923 a new depôt was opened in the south of the town, and a district holder of 200,000 c.ft. capacity, complete with boosting and governing plant, was erected. The holder was a two-lift spiral in a steel tank. Described briefly, gas is drawn by the booster from the town mains (regulated so that the pressure on the mains does not fall below 10-tenths at any one point) after midnight each night, and the holder is filled up in a few hours' time ready for the next day's output.

This scheme has proved of immense value to us, serving as it does the dual purpose of (*a*) storage and (*b*) pressures to points seven miles away from the gas-works.

The following year, 1924, we embarked upon enlarging and remodelling of the carbonizing plant and house. The extensions consisted of three new settings of eights, erection of a complete new structural steel retort house, the demolition of the old and cramped brick building, and the installation of a Guest-Gibbons stoking machine, coal breaking and elevating plant, and electric generating set. The work was started in March and concluded in December, and was most difficult to undertake, as we were adding to and coupling-up new plant with old. The whole of the contract was entrusted to Messrs. Gibbons Bros., of Dudley, working to the author's designs and desires.

As already remarked, this new plant has proved its worth in respect of the better retort house results now being obtained. The scheme has been a means of increasing our out-turn by some 100 p.ct., with little or no encroachment on ground space, and it should be added that the area of the Colombo works is only 121,000 sq. ft. As all the coal used is sea-borne, we need to carry stocks of at least four months' supply (4500 tons), and therefore one will be able to figure out that we are a most confined works.

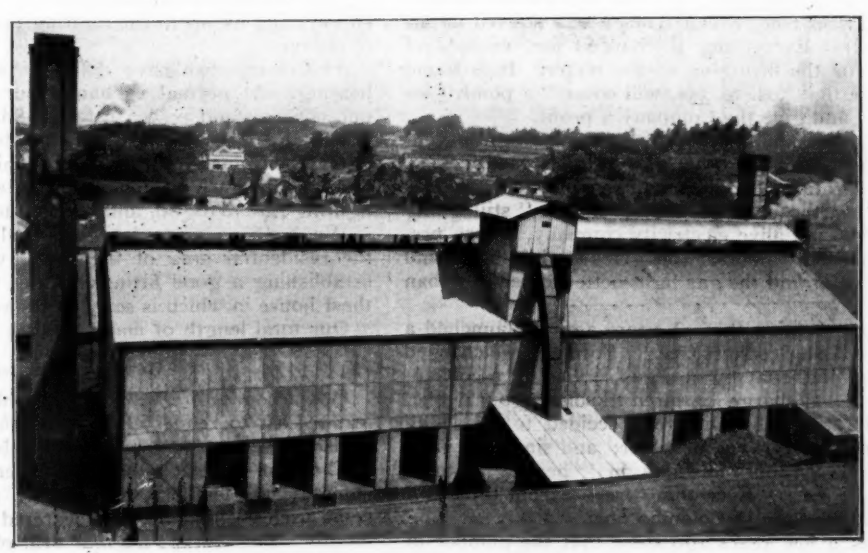


RETORT HOUSE, SHOWING COAL BREAKER AND ELEVATOR.

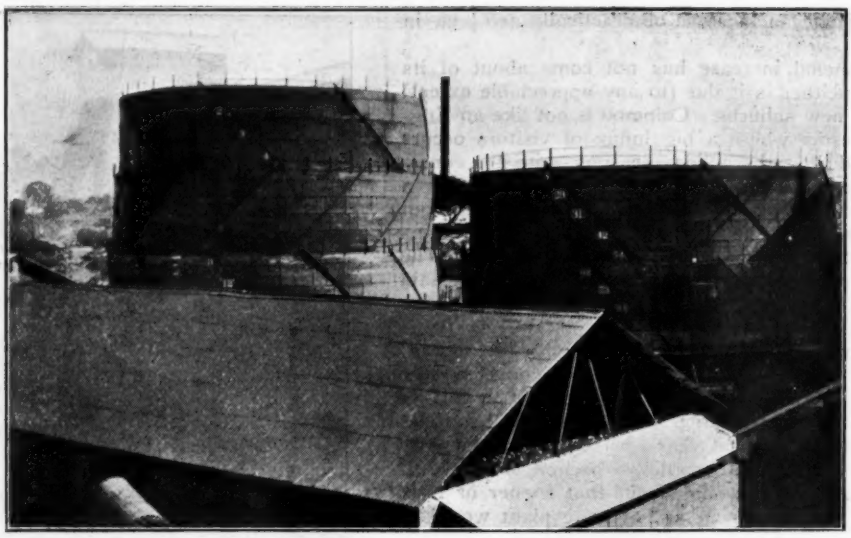
On completion of the carbonizing plant, outputs still continued to increase, and during 1926 and 1927 we undertook two enlargements to our holders, this time on the works where we have three—two old ones erected in 1872 of 90,000 and 60,000 c.ft. capacity (single lifts in wrought-iron tanks), and one erected in 1905, of 160,000 c.ft. capacity (a double lift in steel tank).

After careful deliberation, as we had no room whatever to erect a new holder, we decided to remodel the two old single-lift holders, take out the lifts, and cut the column guides down to tank top level, utilize the same tanks, and convert the holders respectively into three and two lift spirals. The smaller of the two was remodelled in 1926 and made into 125,000 c.ft. capacity, and the other single-lift holder was converted last year into a three-lift holder of 285,000 c.ft. capacity. Both tanks when emptied and cleaned out were found to be in excellent condition, though they had been in commission over fifty years, and both schemes have been of far-reaching importance.

The work of taking out old lifts and guide columns and fitting in a new spiral holder to tanks that were out of



RETORT HOUSE (SIDE VIEW).



TWO CONVERTED HOLDERS.

plumb, and not round, entails far more accurate workmanship than the erection of a brand new holder. All the holder work was carried out by Messrs. Samuel Cutler & Sons, of Millwall, whose work has been of the very best.

The above-mentioned extensions are the most important which have taken place at the gas-works of Colombo for the past twenty years. There have, of course, been other extensions of plant, such as to exhausters, governors, station meter, scrubbers, &c., but this is in reality small work compared with the four main extensions just cited.

Three photos showing the new retort house and the two reconstructed holders are reproduced.

4. FITTINGS DEPARTMENT.

All the gasfitting work in the town is done by the Gas Company; there are very few outside contractors, and what few there are do little work.

The department consists of fourteen fitters, including two mainlaying foremen—or Kanganys as they are termed—and each has his own tools, tool carts, and coolies, and is supervised by a European fittings engineer.

Another engineer controls the private-house repairers—that is, those engaged upon "maintenance"—as well as the stove men, who are occupied upon the monthly maintenance of cookers.

All work is carried out on the job number card system, and the fittings engineer sees the work from start to finish. In the case of a new installation, his men fix the meter also.

As regards new work, most of it is estimated beforehand, and a quotation given. We lay nothing free in connection with a lighting job (only in the case of cookers do we lay services free, which scheme was started at the close of 1924). Everything is charged for, except, of course, that for the fitting-up of the meter. It is found on an average that 30s. to 35s. will cover "a point," including lamp, and give the Company a profit.

We do a great amount of work in pure lighting installations, more than any other gas company east of Suez. Our private lighting load has increased by as much as 75 p.ct. during the past six years, and is "still going strong," despite an alive electricity company, whose premises are next door to ours. Gas gives a white light, and the native element find the gas light better to read by than the electric rays.

I have made mention that 3½ years ago we launched a campaign of "fixing cookers free." Formerly we charged nominal sums for the laying of a gas service for a cooker; but even a nominal charge appeared irksome to our public. After consideration, the Directors decided to waive all charges when a cooker was installed; and since that date we have increased our business in "heating" to a phenomenal degree. "Everything free—except the gas" is a well-known slogan in Colombo now.

Our records a few years ago show that the number of cookers out in the town was under 50. To-day there are nearly 2000. This may not appear a large number to gas engineers in Great Britain; but in a place like Colombo (where no lady of the house cooks) where one has to contend with native cooks—who like to see the blaze of a good fire and who love smoke and dirt, and who, if there is a cooker, waste far more gas than they use, and who are prejudiced against a cooker, for they know they would then lose their little daily "commission" on the purchase of firewood—this increase in our trade can but be considered as eminently satisfactory.

The expense involved in supplying these cookers and laying free services is naturally a big item, but, like advertising, it pays, and more than pays. The strides that are being made in sales of gas for cooking and heating have proved the wisdom of the Company's policy in this respect.

We only charge a nominal sum of one rupee (1s. 6d.) per month hire (any size cooker), and we clean them once a month free. We stipulate a "minimum" consumption of 1000 c.ft. with each cooker.

The maintenance system of private householders allows for our mechanic to call three times a month, and our nominal charge amounts roughly to 6d. per point according to the size of the installation. The man cleans and adjusts the burners, and renews mantles where necessary. Any glassware is an extra.

In connection with hot water geysers and installations, we do not lay the service free as is the case with a cooking stove, but we connect up the supply and fit the water pipes at a little over cost price. The geysers may be hired (at 4s. 6d. per month) or bought outright. When a lighting installation comprises six or eight points, we generally supply, and fix up to the lighting pipe, a boiling ring free of charge.

At Colombo we have different rates for lighting and heating. At normal exchange our lighting rate is 7s., our cooking and power rate 4s. 8d. per 1000 c.ft. For hotels and large consumers our rate is 4s. 4d. per 1000 c.ft. The Council rate is 5s. 8d. This charge includes gas and maintenance. This year we expect to reduce our lighting rate to 6s. 8d. and cooking to 4s. per 1000 c.ft.

We have an up-to-date artistically-built showroom in the residential area of the town, which is a means of establishing a good fittings service to our area, the furthest house in which is seven miles away from the works.

Our total length of mains is 112½ miles.

5. METER DEPARTMENT.

Our accounts are sent out monthly, as it is a practice in the East to render all bills monthly and not quarterly. Consequently our meters require to be read every month.

They are all wet ones (dry meters will not stand the climate; the leathers, particularly, soon harden and become useless), and they are watered as well as read each month. This entails a great deal of work, but it is absolutely necessary. We have some 4500 meters out on

the district, and four men are continually engaged on watering. Eight men cope with the monthly readings. Those we send round are meter fitters; they are not well-versed in English or arithmetic, and so cannot take the index state in plain figures, deduct from the previous month's reading, and so insert, there and then, the actual month's consumption. Instead, there is printed in the meter books an exact replica of a meter dial face, and they mark thereon in pencil the actual position of the index hands.

The calculations and deductions in the books are then undertaken by the office.

Meters are fixed free, and low monthly rentals are charged, varying with the different sizes. A 3-light rent is 4d., a 5-light is 6d., and so on. All service pipes (and, indeed, all internal piping) are of galvanized iron; the meter connections being of lead. All our meters are specially made to withstand 5 in. head of water pressure. We do all our own meter repair work and testing. Every meter bears the Municipal Inspector's seal.

6. Public Lighting.

The author has always been a keen exponent of gas for lighting, and particularly public lighting, for he holds that up-to-date and well-kept street lamps are a constant source of advertisement.

In most cities of the world efficient public lighting has become a more complex and important matter than in the past. Increase in the speed and volume of street traffic has brought about great advances in standards of what constitutes satisfactory street lighting; and Colombo has been no exception. Good lighting is essential for the safety of traffic and pedestrians. Widening of roads, rounding of corners, and other measures involve much expense, whereas improvement in street lighting is one of the simplest and least expensive methods of promoting the safety of the public. In this connection, the International Commission on Illumination is rendering most important services to all the gas undertakings in the world. The author therefore hopes that at the Commission's forthcoming plenary session at New York next September the Institution of Gas Engineers and other British organizations will be well represented.

Since the Company started operations in Colombo in 1872, practically all roads have been gas lighted. During the early years the burners were all of the flat-flame type, and in 1880 our records show that some 1200 were in use. The Welsbach incandescent mantle was invented in 1887, but it was not till the year 1900—some 28 years after Colombo had been first illuminated—that the change-over to the incandescent system was made, and a new contract signed with the Municipality. The number of such lamps then involved was 1700, and the burners employed were the old type No. 3 Kern uprights fitted in ordinary hexagonal copper lanterns. These lanterns were specially constructed at that time, and are termed "Bombay" lanterns —so-called, probably, from the city in which the lantern first appeared. They were made originally by Messrs. Pintsch & Co., of Berlin, have both primary and secondary air supplies, and are as near as possible wind, rain, and insect proof.

Peculiarly enough, the self-same type of lantern is in use to-day, carrying, of course, more up-to-date fittings.

Continuing from 1900, when the new system was adopted, the number of street lamps gradually increased to some 2500 just before the war. They all contained the Kern burner; no arc lamp lighting system being in vogue. This total of street lamps (2500) continues more or less to be the number to-day, but, of course, greatly rearranged as to type and fixture.

It may be of interest to cite the ups and downs of our public lighting system during the war years. During those four long years, everyone's business was, in his own opinion, the hardest hit, by the restrictions imposed by Government; but looking back, it will be generally accepted that no utility service was ever so disorganized or so disturbed as the public lighting department of a city, and especially of a town bordering on the sea coast. Colombo was again no exception to the rule.

At the commencement of hostilities it will be recollected that the "Emden" was hovering in Eastern waters, and all lamps facing seawards had to be extinguished. A policy of retrenchment obsessed the Council during the years 1915, 1916, and 1917. All lamps were reduced in candle power, and the lanterns were painted or tarred to within an inch or so of the bottom. In February, 1918, our lighting restrictions were removed, and it was thought that a turn for the better would take place, and that our public lighting load would increase. Any such idea was upset through failure to obtain adequate coal supplies from India. In April, in order to eke out supplies, the pressure of gas was reduced each evening at 9.0 p.m. so as to effect an almost non-supply. In May a shipment of coal had been received, and it was decided to revert to normal gas pressure from that date. Towards the end of that month, however, it became evident that restrictions on public lighting would again have to be introduced owing to the further difficulty of securing coal. Government urged upon the Municipality the necessity—from an Imperial standpoint—of economizing in the use of coal; and it was then decided that all half-night street lamps be turned out at 10.0 p.m., instead of midnight. This took effect from June 4. This was followed by an order to discontinue lighting all half-night lamps after June 15, leaving only some 260 street lamps alight in the town, out of a total of 2500.

The decrease in gas for public lighting in 1918 was equal to 55 p.ct. on the 1917 figures—a very serious decrease.

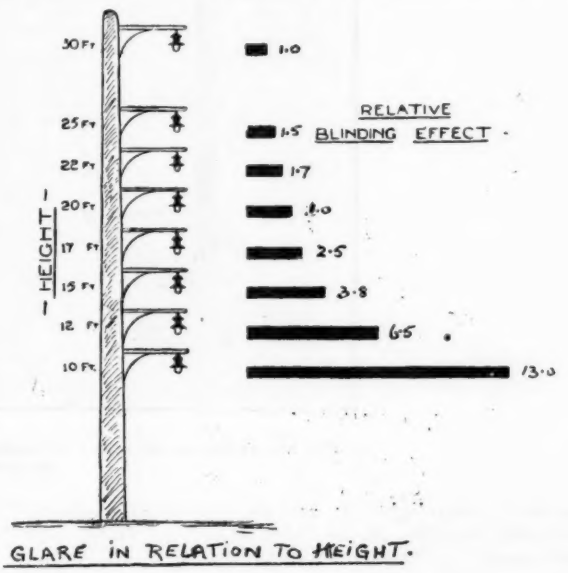


Fig. 1.—Glare from Gas Arc Lamps.

In 1919, after cessation of hostilities, the Council decided to cut out their retrenchment policy in so far as street lighting was concerned, and in January 1000 half-night lamps were re-lighted. This was followed up by a further 200 being lighted in April on account of reduction in the price of gas then offered.

In 1920 a further price reduction was made, by reason of cheaper coal, and so a few more lamps were re-lighted.

During 1921, steps were taken to introduce better lighting of the street junctions, and generally to convert the old No. 3 Kern upright Welsbach burners on to more modern lines of street lamp lighting. With a view to getting the Council to light all the lamps in the town, it was agreed upon that for the minor roads and lanes, a burner of smaller candle power than the ordinary No. 3 burner would suffice; and the best product the author could suggest was the No. 1 bijou inverted "conversion fitting," manufactured by Messrs. William Sugg & Co. Samples were sent out and put on trial, and it was decided that, by using a convex reflector and bijou burner as against the ordinary concave reflector and No. 3 burner, quite a satisfactory light could be obtained, sufficient for minor roads, &c. Accordingly these were ultimately decided upon, and 1600 of such fittings were fixed in the street lanterns in 1922.

In addition to the suggestion of conversion from upright to inverted burners in so far as the bijou fittings were concerned, the author also commenced a movement to secure better lighting of junctions and main roads by

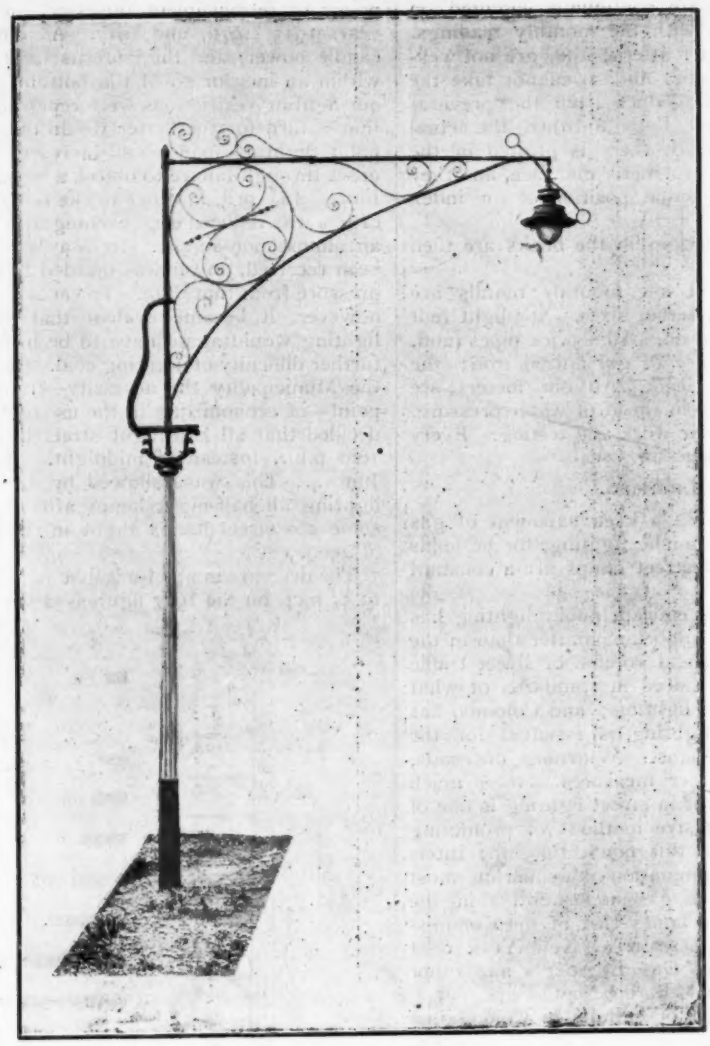


Fig. 1A.—FLEXIBLE BRACKET ATTACHMENT TO ORDINARY STREET LAMP COLUMN.

means of arc lamp lighting; and the type of lamp experimented with was the 3-light "Littleton" arc lamp, also manufactured by Messrs. William Sugg & Co. The Mayor, municipal authorities, and police all inclined to the belief that "central lighting" was the only real way of satisfactorily and safely lighting busy thoroughfares. In this year motor traffic began to assert itself, and between 1921 and 1927 the increase in vehicular traffic on the Colombo roads has been truly enormous.

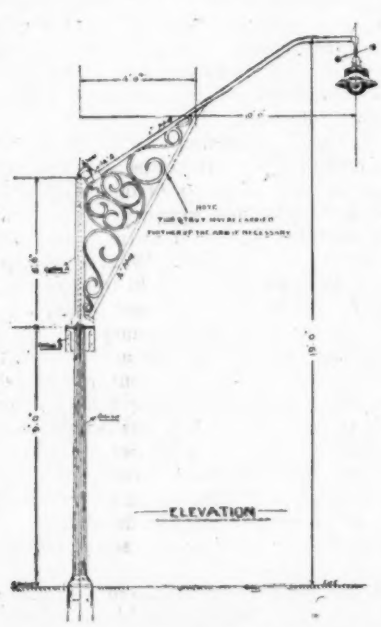


Fig. 2.—Bracket Attachment to Ordinary Street Lamp Column.

After several months of experimenting, the idea of attaching a bracket arm to the present street lamp columns, raising the height of the lamp, extending the arm of the bracket some 8 ft. into the road, and attaching an arc lamp thereto, seemed to be a simple, as well as an ideal, way of producing "central lighting;" and in July, 1921, the author designed the first bracket, which was then erected in the town and which at once received the entire approval of all parties.

Since that date, a few minor alterations and improvements have been effected to the "swing-arm-bracket" idea, but the general arrangement remains. Briefly the bracket suspends the lamp 8 ft. out into the road and 13 ft. above road-level. Fig. 1A is a photograph of the lamp and bracket. The idea is unique to Colombo. The bracket costs about £2.

Columns carrying arc lamps are spaced 80 yards apart on the hit-and-miss principle. The ordinary street lamp columns are spaced 70 yards on the main roads and 75 in minor roads.

The maintenance upkeep of these suspended arc lamps is particularly low, and hereunder are given our results from 1922 onwards of "mantles per burner per annum" for these particular lamps:

Year.	Mantles per Burner per Annum.
1922	2·61
1923	2·53
1924	3·29
1925	3·51
1926	4·19
1927	4·20

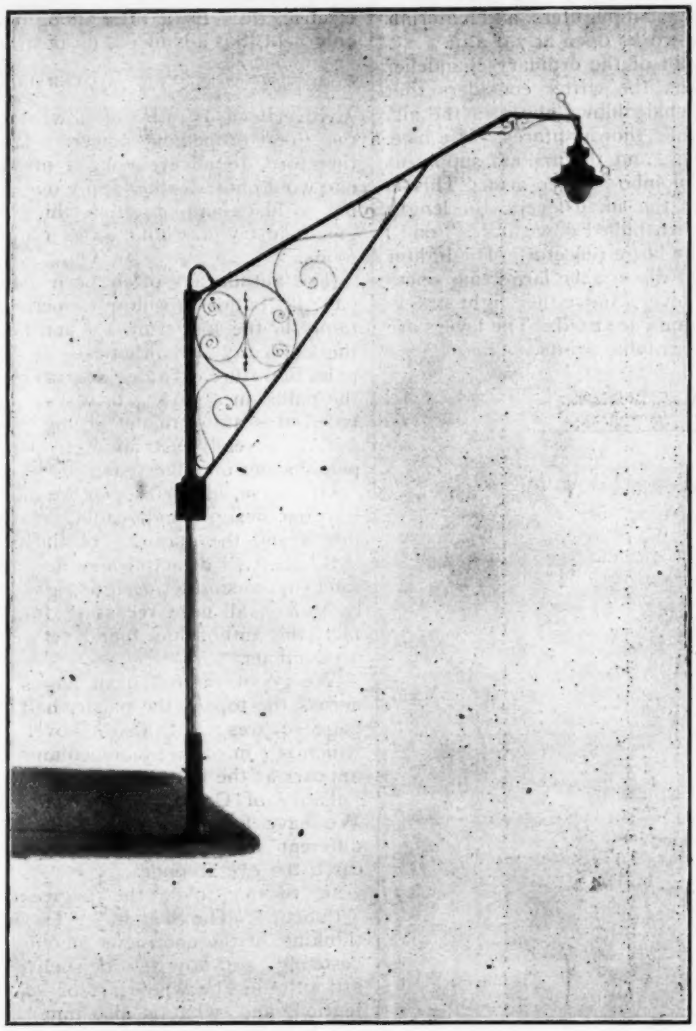


Fig. 2A.—RIGID BRACKET ATTACHMENT TO ORDINARY STREET LAMP COLUMN.

At the close of 1927 we had 333 arc lamps erected, and a total of 276 globes were issued for replacements, so that on the average it may be taken that a lamp needs a new globe once in fifteen months.

The year 1921 therefore saw the real advent of street lighting at Colombo by inverted burners and arc lamps; and we have steadily developed this system—arc lamps on the main roads and either No. 1 bijou, 2-light, 3-light "A" pattern, or 5-light "A" pattern burners on connecting roads. In 1927 we extended our mains to a point seven miles south of the gas-works to a seaside resort known as Mt. Lavinia. The road from Colombo to this suburb is as near as possible a straight one; and this long row of seven miles of gas arc lamps, their lights scintillating against the eastern sky and amid eastern surroundings, is worthy of gas in the highest degree. The gas used for street lighting last year was 11¾ p.ct. of the total output.

Of late years the trend of street lighting practice has been towards (*a*) closer spacing and (*b*) greater mounting heights. The first is self-explanatory. The second point deserves note. In the specification of the patent bracket attachment already described, the lamp is shown to be some 13 ft. above the crown of the road. The author considers this to be sufficient for 3-light arc lamps; but for higher power lamps (5-light and upwards) 15 ft. should be regarded as a minimum, and (say) 20 to 25 ft. as a maximum. Avoidance of glare is to be particularly watched, and the two methods of minimizing this are to increase the mounting heights (as just referred to) or to use a diffusing globe.

All our arc lamps are fitted with globes frosted two-thirds from the bottom up, and they tone the light down perfectly without any serious diminution of candle-power. The lamps when lighted present a very pleasing effect. A small diagram showing the "relative blinding effect" of glare from arc lamps is appended (fig. 1), and is instructive. A hemispherical polar curve of Sugg's 3-light "Littleton" lamp with clear and frosted globes is given in fig. 4.

In respect of providing a greater mounting height for the lamps, a further bracket attachment to the ordinary street lamp columns has been designed; and sketch of same is given in figs. 2 and 3. A photo of the bracket attached to the column is also shown (fig. 2A). This attachment is perfectly satisfactory. It differs from the first patent design in being a rigid fixture. The cost of this bracket is about £4.

Routine Work.—In the matter of lighting and extinguishing lamps, we have a total of 45 lamplighters. These men light and extinguish the lamps whether "half-night" or "all-night." They have nothing to do with the cleaning of the burners or lanterns. They are provided with Simmance-Abady flash torches, and are also provided with khaki coats and hats with "Gas Co." stamped thereon in red cloth.

The lamps and burners are attended to and cleaned by a staff of 18 "public lamp repairers." Their work consists solely in renewing mantles, chimneys, &c., adjusting burners, and cleaning the lanterns. They are provided with Ross lamp climbers, manufactured by Messrs. Alder & Mackay, Edinburgh.

Two lamp inspectors supervise the native workmen. The Council also has a Public Lighting Inspector, who sends in his report to the Company two or three times during the week. The Company's lamp inspectors are provided with bicycles, as are several of the lamp repairers who have large areas to control. Reports are

brought in each morning by the lamplighters, and materials are given out as soon as the works open at 7.0 a.m.

The arc lamp levers are not of the ordinary chandelier chain "off-and-on" type, as the writer considers that such a design in which the chain blows about in the air, looks exceedingly bad in public thoroughfares. We have dispensed with this altogether, and the makers supply us with what is termed a "Colombo" lever arm. This is really an enlarged edition of the small lever; the length being such that the lever when pulled down (*i.e.*, "on") just extends to the edge of the large reflector. The lighter with his hooked pole can just discern the large ring opening at the end of the cast lever, and either light or extinguish the lamp, and no chains are used. The levers are clearly seen in the two photographic prints.

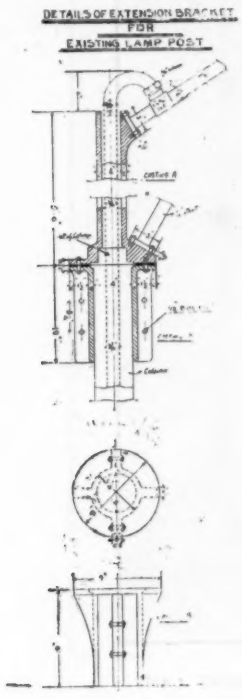


Fig. 3.—Bracket Attachment to Ordinary Street Lamp Column.

The writer has dealt rather at length on public lighting, for, apart from its being a very important branch of the business, it has a fascination. Gas was first introduced for street lighting; and considerable historical and sentimental interest therefore attaches to this portion of a gas company's business.

He can truly say that the patent bracket-attachment device saved the Colombo Gas Company from losing its public lighting load. At the time all the authorities were pro-electric and in favour of central lighting. The Electricity Company came into the field with all sorts of gadgets, offering to displace three gas lamps by one

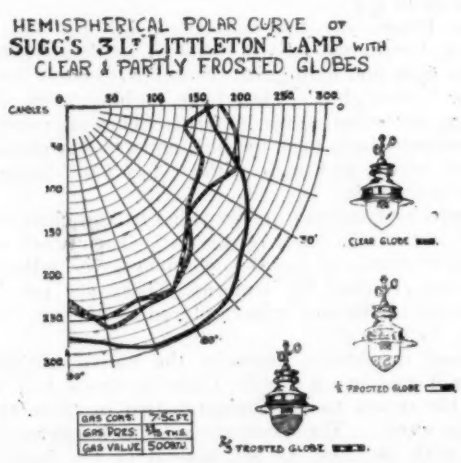


Fig. 4.—Hemispherical Polar Curve.

electric, &c. By a little thought and scheming, gas not only held, but advanced, its position.

7. Advertising.

Advertising is to business what steam is to machinery—the great propelling power. Trade follows the light; therefore, to advertise light means to induce trade. If one would but steadily apply one's early training in drawing to black-and-white sketching, one can develop in the gas industry a whole series of advertisements and cartoons.

The author has often been asked, "Does advertising pay?" It does absolutely—perhaps not at first, but certainly in the long run. When he went out to Colombo, the Company had practically no advertisements or pamphlet literature. To-day several gas slogans appear before the public in a variety of ways, and the number of letters received stating that "seeing your advertisement . . . &c.," is really astounding. We never begrudge one penny spent on advertising.

Of course, in the Tropics we must introduce local colour into our designs and reading matter. English advertisements and the majority of the pamphlets issued by the "B.C.G.A.," depicting gas fires, or ladies cooking in the kitchen, wash-day designs, gas fitters in trousers and caps, &c., all need recasting for local requirements. In fact, the author has found very little help from English productions.

We go in for full front pages of the local papers, or across the top of the paper, half or quarter depth, front page squares; and also a novel "small advertisement," which is ¼ in. deep by one column (about 2¼ in. long), and appears at the bottom of the reading columns of our daily "Times of Ceylon," the island's principal newspaper. We have five insertions a day, including Sundays, all different in design. They are really outstanding, and catch the eye at once.

In turning over the pages of such magazines as "Punch," "The Sketch," "Tatler," &c., one cannot help thinking of the enormous amount of money spent on advertising, and how few of such advertisements are really attractive. The whole art of advertising is to arrest attention, and, what is also important, to vary, or rotate, one's designs in any particular paper or magazine. To keep the same design appearing week after week is sheer waste of money. "Crowding" an advertisement is also to be avoided.

Truth is a big item in advertising principles. When experience confirms the advertised statements, a good reputation is built-up. When the reverse happens, that self-same experience does infinitely more harm than the advertisement does good to the advertiser.

The author does not favour "bad publicity," by which he means that there is no good sense resulting in referring in a depreciatory way of a rival. It is a waste of time slinging mud at your competitors.

Apart from daily newspaper advertising, we go in for pamphlets, and more often than not we send out about once a quarter a pamphlet with our bills. Whenever a new meter is fixed, we automatically mail the consumer two pamphlets, one "How to Read the Meter," and the other "The Light that Satisfies"—a booklet dealing with the incandescent burner. These two booklets are mailed in an envelope with a "compliments" slip attached. We superscribe our envelopes at times with advertising matter, and issue artistic blotters and calendars—all of local interest, and all from our local designs and printers. Directories, mail steamer "Books on Ceylon," &c., all come within our scope of booming gas, as well as cinema programmes and gas films. Messrs. Radiation's film "A Happy Ending," advertising cooking by gas, was brought out and shown by us at the local cinema over two years ago. It was the first "publicity" film to be shown in the island, and attracted much attention. Advertising pays; and if you can do your own sketching and designing, and so avoid payment of heavy artist fees, it pays doubly.

8. Keeping Abreast of the Times.

In the East one must keep abreast of the times in more ways than one. It is necessary to keep a good control on indents and shipments. With Colombo, at least two

to three months must elapse between the time goods are ordered (by mail) from England, and received at the gas-works. In the case of Continental supplies, such as mains, glassware, &c., a considerably longer time is required. And so one must look and gauge things ahead. We are not in as fortunate a position as our English confrères who can 'phone through to engineers or suppliers in cases of breakdowns for spare parts, and so get fixed up at once.

And apart from keeping pace with indenting, one must keep pace with the trend of thought and investigation on all matters relating to gas, either by close perusal of the several gas journals to hand week by week, or by direct communication with the leading makers of gas appliances. The Colombo Gas Company can claim to have looked well ahead.

In going through some old papers, the writer recently came across a somewhat lengthy extract which appeared in the columns of the "GAS JOURNAL" as far back as February, 1907—over 21 years ago—in which it is stated that the Colombo Gas and Water Company had made a contract with the Municipality which "stands unique in the history of gas supply."

Twenty-one years ago, then, we were recorded as being first in the field, in respect of a gas contract which was nothing more nor less than a contract based on calorific value. In the years preceding 1907 our contract stipulated an illuminating power of 15½ candles, with no reference to B.Th.U. at all. The new one defined a 10-candle gas with a minimum of 400 B.Th.U.; and we are in broad terms working to that contract to-day, though supplying a 450 B.Th.U. gas.

In 1907 the Company undertook to maintain a 60-C.P. light with the incandescent burner in the ordinary street lamps; and it was found that even with an 8-C.P. gas a light of 72 C.P. could be obtained with a carefully adjusted No. 3 Kern burner consuming 3½ c.ft. per hour.

So long ago as quoted, therefore, and as far away as Colombo, it was opined that the general future of gas supply would be on the calorific basis, and also that the bare illuminating power would be as low as—if not lower than—10 candles.

A few years ago the author remembers reading in the Technical Press that one gas company in England had adopted the "novel and unique" method of utilizing the gasholder as an advertising medium, the words "Gas for Lighting, &c.," having been lettered thereon. For many years past we have had our holders at Colombo emblazoned with the slogan "Cook by Gas."

Then again in such matters as coke and tar sales, "maintenance" details, and other items affecting business, we have had to be continually on the alert, anticipating matters, not being able to hold or attend conferences or debates and get grip of the best of ideas as is the case at home. In short, one has to be constantly keyed-up in a public utility position abroad, keeping in touch with all that is latest and best. The secretary of a company can be of immense help to the local manager in this respect of mailing out the latest ideas and drawing attention to various papers and discussions.

9. Advice to Those Going Abroad.

Although having had nearly fifteen years' experience abroad (at Colombo, five years of which were in the capacity of Deputy-Manager), the writer is still a young man; but fifteen years is, he thinks, sufficient qualification upon which to base some advice; and before closing his paper he would like to devote some few remarks to those young gas engineers who may have thoughts of one day going out East, and his remarks are made in all sincerity and with the best intentions.

At the outset, he would point out that no one can visualize the East, its ways or methods, unless he goes there. It is impossible to "read it up" from books. The average young man, and even the average old man, looks upon a post in the Tropics as one of ease and of pleasure. It is, if one has no responsibility at all, or if one does not wish to show progress or to show value for money, or if one wishes to die young. It is to be admitted that it is very easy out East to "go slow," and the great sage who wrote some 2000 years ago—"Yet a little sleep, a little slumber, a little folding of the hands to sleep"—truly depicted the Easterner and his ways. An assistant in the gas industry, no matter in what department he may be or no matter how ordinary his work, can, if he chooses, make his work an extraordinary success. This brings interest to the most humdrum occupation. But unfortunately the young men going abroad to-day fall (some on the steamer before they even land at their destination) a victim to the line of least resistance. Everything is new; they get inflated with ideas totally beside the point of hard work; and their characters, which, granted in England, are all to be desired, become undermined. It is a fatal mistake for a young man to go abroad and to think that he is leaving hard work behind him. To make a success of such a business as gas in a tropical climate, coupled with the dealings of such a heterogeneous mixture of races and castes, is by no means an easy matter.

A point which should not be forgotten is that from the start one must enlist the sympathy of the native workmen. One must listen to their grievances, and not treat them as nonentities.

The East offers, and continues to offer, splendid opportunities to the right man—the right man, not as viewed in England, but the right man as viewed abroad. Working with a Company and with such a sincere and sympathetic Board of Directors as has been the author's privilege, makes work easier than otherwise might be the case, and tends towards mutual trust and contentment; and yet some of our own Assistants have literally thrown careers away.

To the young gas engineer therefore who has aspirations towards the East, the writer's advice is to carry on with your Western creed of character and determination, right from the day you set sail from England. We none of us should forget that in the days of Rome the Temple of Fame was always placed behind the Temple of Virtue, because it was said that no one could enter the one without going through the other; and we should remember the moral conveyed by that classic image—that the path of duty was also the way to glory.

He trusts that the foregoing remarks will be of some interest and of some assistance, particularly to the young men present at the Cardiff meeting of our great Institution, soon, he hopes, to be raised to the distinction of being incorporated by Royal Charter. Fresh troubles are always arising on a gas-works. Day by day some new anxiety, some new problem, has to be grappled; and each and every assistant on an Eastern works must realize that nothing short of his best must be forthcoming if any success is to be recorded. The success of any professional Institution is the sum of the successes of the individuals in that Institution; and it is all too true out abroad.

Before concluding, the author desires to take this opportunity of making reference to one who is well known to every member of the gas engineering profession; one whose sound advice and friendly interest was behind him when he left England years ago. He refers to Mr. John Young, who was President of the Institution so long ago as 1916, and under whom he was trained at the Hull Station of the British Gas Light Company. He was articled pupil to Mr. Young, and spent many happy years at his works, both during and after training. We all know Mr. Young for his "cheery briskness," and the author is happy to think he has modelled his own life in the Tropics in the reflection of one who took such a personal interest in his early gas years. If only the majority of gas engineers would extend such kindly actions as Mr. Young did to the writer nearly twenty years ago, he ventures to think a better and a more thorough type of gas engineer would be the outcome.

INSTITUTION GAS FELLOWSHIP 1928 REPORT.

I.—INTRODUCTION AND SUMMARY.

In preceding reports the results have been given of numerous tests on the reactivity of cokes made with and without the addition of inorganic constituents. These cokes had been in nearly every case prepared by carbonization at 800° C., gradually heating to the maximum temperature in three hours and maintaining at that temperature for another three hours—six hours in all. It was desirable to determine how far the reactivity was influenced by the temperature of carbonization, and for this purpose cokes prepared at 500° C. and 1100° C. with and without the addition of inorganic constituents were tested for their reactivity in steam, the test being made at temperatures suitable for obtaining the best comparative data. It was found that the coke prepared at 800° C. had the maximum reactivity in every case, 500° C. distinctly lower, and 1100° C. lower still. This result is consistent with observations made by Greenwood and Cobb on "The Structure of Coke" (J.S.C.I., 1922, p. 181), when an 850° C. coke was found to be characterized by greater porosity and thinner walls, as compared with 550° C. and 1150° C. cokes. The influence of the inorganic constituents in enhancing the reactivity was found to be marked in all the cokes examined at all temperatures. The results are summarized below :—

—		Carbonization Temp. 500° C.	Carbonization Temp. 800° C.	Carbonization Temp. 1100° C.
Description		P.Ct. Steam Decomp.	P.Ct. Steam Decomp.	P.Ct. Steam Decomp.
"Pure" coke	Tested	48·9	62·7	28·2
Iron oxide coke	at	86·4	91·4	79·2
Calc. carb. coke	1000° C.	72·8	80·0	64·5
Sod. carb. coke "dry"	Tested	78·0	95·0	60·0
Sod. carb. coke "wet"	at	75·7	..	71·3
Potass. carb. coke	800° C.	68·3	86·0	55·1

It was plainly important as bearing on the reliability of our tests on reactivity, and for more general reasons, to ascertain whether the reactivity of a coke prepared at one temperature remained the same when it was maintained for a considerable time at a higher temperature, and experiments made to this end showed that the reactivity of 500° C. coke was very little affected by a previous heating in nitrogen for several hours at 1000° C. Moreover, a coke prepared at 500° C. and gasified in steam at 1000° C. for the determination of reactivity decomposed steam at substantially the same rate, and gave in other respects the same results, *throughout* the test, although this represented several hours of heating to a higher temperature than that at which the coke had been prepared. Although the influence on reactivity of heating for a period of some hours at a temperature well above that of preparation is so small, it is not maintained that very prolonged heating is without its effect on reactivity, since in one experiment it was demonstrated that heating a coke prepared at 800° C. for 50 hours at 900° C. did cause a considerable diminution in reactivity.

The work so far summarized is described in Part I. (*a*). Part I. (*b*) deals with the influence which the presence and decomposition of hydrocarbon and other gases, in contact with coke at high temperatures, may exercise. Such a consideration is plainly of importance because of the presence of gases during carbonization. The influence on the reactivity in carbon dioxide of previously treating a "pure" coke with hydrogen, carbon monoxide, methane, or ethylene for one hour at various temperatures was ascertained. (*v.* Tables III. and IV., figs. 2, 3, and 4.)

The cokes so treated with CO and hydrogen behaved very similarly. Each of them had after treatment an initial reactivity rather less than that of untreated coke, but after gasification in carbon dioxide for two hours, the difference in reactivity had disappeared. Treatment with methane lowered the reactivity in a very marked manner, particularly at the higher temperatures (900° C. and 800° C.) employed. It was noticeable that this effect, for example at 800° C., was great when the actual decomposition of methane was hardly detectable by chemical analysis. The impairing of reactivity was somewhat lessened when the carbon dioxide had been passed for two hours. Ethylene had an even more marked effect than methane, slightly so at 900° C. and 800° C., and more decidedly so at 700° C. and 600° C. The decomposition of ethylene was, however, much more extensive than that of methane, and at 800° C. and 900° C. there had been considerable deposition of bright "methane" carbon on the coke, which from its quantity must have come from the ethylene, but not as a secondary decomposition product of methane derived from the initial decomposition of ethylene. The influence of this considerable deposition of carbon was plain after treatment at 900° C. with ethylene, in that, even after 52 hours' passage of carbon dioxide, the very low value for reactivity of the coke remained practically unaltered.

The experiments described in I. (*a*) and I. (*b*) lead to the following view. When the charge on carbonization has reached the desired maximum temperature, and is kept there for some hours, a structure with a corresponding reactivity is impressed upon the coke, and is characteristic of a coke prepared and *held* at that temperature. When a coke has been so prepared, further heat treatment for some hours in a neutral atmosphere such as nitrogen does not materially affect its reactivity, although very prolonged treatment over some days will do so. (This emphasized the importance of the rate of heating through different temperature ranges as a factor in influencing the reactivity of the coke finally made.) If, however, the coke is subjected to the action of hydrocarbon gases, particularly at temperatures from 700° C. upwards, the reactivity of the coke is impaired, even when the amount of decomposition of the hydrocarbons is quite small. If the temperature is high and much deposition of bright "methane" carbon on the coke takes place, the effect is much more marked, and persists very much longer while the carbon is being gasified.

SOME FACTORS INFLUENCING REACTIVITY OF COKE.

I. (*a*). Carbonizing Temperature and Heat Treatment in Nitrogen. By J. A. SUTCLIFFE and J. W. COBB.

PREPARATION AND DESCRIPTION OF COKES.

Five p.ct. additions of sodium oxide, calcium oxide, and potassium oxide (added as their respective carbonates) and a 5 p.ct. addition of iron oxide were made to the Sharlston Wallsend coal (Haigh Moor Seam). The coal mixtures and a quantity of the untreated coal were then carbonized at 500° C. and 1100° C. respectively for comparison with cokes previously prepared at 800° C. The potassium carbonate was incorporated with the coal by making a strong solution containing the required quantity of potassium carbonate. The coal was well mixed with the solution and dried at 105° C. A coke was also prepared containing sodium carbonate which had been incorporated with the coal in this manner in order to make a comparison with the coke obtained by mixing the coal and sodium carbonate in the dry state. These cokes will be referred to as sodium carbonate coke "wet" and sodium carbonate coal "dry."

Cokes Prepared at 500° *C.*—The "pure" coke was very swollen and spongy. The coke containing calcium carbonate was similar in appearance but harder. The cokes containing iron oxide, sodium carbonate, and potassium carbonate were, however, finely porous and homogeneous. Of the three the former two were hard, but the latter coke was soft and friable and of a dull black colour resembling that from a poorly coking Nottinghamshire coal.

Cokes Prepared at 1100° *C.*—The "pure" coke, although spongy, was hard, and a considerable portion of the

TABLE No. I.—500° *C. Cokes* (10 *Grams at* 10 *Litres Steam per Hour*).

Description.	Temp. of Gasification. °C.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming in Minutes.	Steam Decomposed. P.Ct.	Coke Gasified. P.Ct.	Coke Gasified. Grams per Hour.	Vol. of Dry Water Gas Produced. Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact. Seconds.
"Pure" coke	1000	I	1	10·80	30	48·9	19·0	3·8	9·61	0·89	0·81
Calc. carb. coke	,,		2	10·43	30	72·8	33·2	6·6	14·41	1·38	0·76
Iron oxide coke	,,		3	11·17	30	86·4	33·0	6·6	18·85	1·69	0·69
Sod. carb. coke "dry"	800		4	10·20	30	78·0	26·8	5·4	15·13	1·48	0·77
Sod. carb. coke "wet"	,,		5	9·17	30	75·7	27·6	5·5	13·34	1·45	0·82
Potass. carb. coke	,,		6	9·22	30	68·3	23·4	4·7	11·62	1·26	0·85

TABLE No. I. (*continued*).

Experiment No.	Litres per Hour at N.T.P. of Wet Gas Constituents.								$\frac{CO}{2CO_2}$	$\frac{CO}{CO+CO_2}$	$\frac{(CO)(H_2O)}{(CO_2)(H_2)}$	Dry Gas Compositions. Percentages by Volume.			
	CO_2.	CO.	$CO+CO_2$.	H_2.	H_2O.	H_2+H_2O.	CH_4.	N_2.				CO.	CO_2.	H_2.	CH_4.
1	1·07	3·27	4·34	5·27	5·52	10·79	0·27	5·1	5·41	0·752	3·18	33·1	10·9	53·4	2·6
2	1·21	5·42	6·63	7·79	2·84	10·63	0·15	5·4	7·84	0·818	1·64	37·2	8·3	53·5	1·0
3	0·78	8·20	8·98	9·87	1·52	11·39	0·18	5·5	9·76	0·914	1·62	43·1	4·1	51·9	0·9
4	1·35	5·38	6·73	8·41	2·25	10·66	0·11	5·2	8·08	0·800	1·07	35·3	8·9	55·2	0·6
5	1·27	4·56	5·83	7·50	2·23	9·73	0·10	5·6	7·10	0·782	1·07	34·0	9·5	55·8	0·7
6	1·48	3·42	4·90	6·72	2·93	9·65	0·15	5·4	6·38	0·698	1·01	29·1	12·6	57·1	1·2

TABLE No. II.—1100° *C. Cokes* (10 *Grams at* 10 *Litres Steam per Hour*).

Description.	Temp. of Gasification, °C.	Series No.	Experiment No.	Rate of Steam Supply. Litres per Hour at N.T.P.	Duration of Steaming in Minutes.	Steam Decomposed, P.Ct.	Coke Gasified, P.Ct.	Coke Gasified, Grams per Hour.	Vol. of Dry Water Gas Produced. Litres per Hour at N.T.P.	Vol. Dry Water Gas / Vol. Steam Supplied.	Average Time of Contact, Seconds.
"Pure" coke	1000	II.	7	10·94	39	28·2	9·2	1·4	5·47	0·50	0·85
Calc. carb. coke	,,		8	11·00	30	64·5	17·6	3·5	12·91	1·17	0·77
Iron oxide coke	,,		9	10·12	30	79·2	23·0	4·6	15·31	1·51	0·78
Sod. carb. coke, "dry"	800		10	9·91	30	60·0	13·6	2·7	10·13	1·02	0·85
Sod. carb. coke, "wet"	,,		11	9·59	30	71·3	16·3	3·3	11·76	1·23	0·85
Potass. carb. coke	,,		12	9·99	30	55·1	11·6	2·3	9·05	0·91	0·86

TABLE No. II. (*continued*).

Experiment No.	Litres per Hour at N.T.P. of Wet Gas Constituents.								$\frac{CO}{2CO_2}$	$\frac{(CO)(CH_2O)}{(CO_2)(H_2)}$	Dry Gas Compositions. Percentages by Volume.			
	CO_2.	CO.	$CO+CO_2$.	H_2.	H_2O.	H_2+H_2O.	CH_4.	N_2.			CO.	CO_2.	H_2.	CH_4.
7	0·73	1·74	2·47	2·99	7·86	10·85	0·17	5·1	3·20	0·704	6·23	30·9	13·0	53·1	3·0
8	1·40	4·51	5·91	7·01	3·90	10·91	0·10	5·3	7·31	0·763	1·79	34·7	10·8	53·9	0·6
9	0·99	6·34	7·33	7·98	2·10	10·08	0·17	5·1	7·32	0·865	1·69	41·0	6·4	51·6	1·0
10	1·73	2·43	4·16	5·97	3·96	9·93	0·12	5·3	5·89	0·584	0·96	23·7	16·9	58·3	1·1
11	1·55	3·55	5·10	6·67	2·76	9·43	0·19	5·3	6·65	0·696	0·95	29·7	13·0	55·8	1·5
12	1·71	2·02	3·73	5·32	4·48	9·80	0·12	5·2	5·44	0·541	0·99	22·0	18·6	58·1	1·3

outside possessed a bright silvery lustre. The coke containing calcium carbonate resembled the "pure" coke in structure but lacked lustre. The cokes containing iron oxide and sodium carbonate were very hard and finely porous. The sodium carbonate coke had pronounced blue markings. The coke containing potassium carbonate was soft and friable, but finely porous and deep blue in colour.

The results obtained on gasification of these cokes in steam are given in Tables I. and II. Table I. and I. (continued) show the figures obtained for the cokes prepared at 500° C.; Tables II. and II. (continued) show the figures obtained for the cokes prepared at 1100° C. In order to facilitate a comparison between the cokes prepared at different temperatures, the "pure" coke and the cokes containing calcium carbonate and iron oxide were gasified in steam at 1000° C., whilst the more reactive cokes containing sodium carbonate and potassium carbonate were gasified at 800° C. The results show that, utilizing the figures quoted in the Gas Research Fellowship Report for 1927, the cokes prepared at 800° C. are the most reactive and the cokes prepared at 1100° C. are the least reactive. The 500° C. cokes occupy an intermediate position. The influence of the inorganic constituents in enhancing the reactivity is marked at all three temperatures of carbonization. The sodium carbonate coke prepared and gasified at 800° C., which decomposed 95 p.ct. of steam, gave a water gas containing only 1·7 p.ct. of CO_2. The sodium carbonate cokes prepared at 500° C. and 1100° C., which decomposed a lower percentage of steam and gave a water gas containing 8 p.ct. and 16·9 p.ct. of CO_2 respectively, the temperature of gasification being 800° C. in each case. In this connection the values obtained for the equilibrium constants are significant.

It was plainly important as to whether the reactivity of a low-temperature coke remained the same when the coke was maintained for a considerable time at a temperature above that at which it has been carbonized. It seemed possible, for example, that a coke prepared at 500° C., which was gasified at 1000° C., would decompose a greater percentage of steam at the beginning of the experiment than it would after the experiment had proceeded for some time, owing to a tendency of the coke to come gradually to resemble a coke which had been carbonized at 1000° C. This point was tested in two ways. The reactivity of a sample of "pure" coke prepared at 500° C. was determined by the method described in the Gas Research Fellowship Report for 1927, the experiment being commenced immediately the temperature of the furnace reached 1000° C. A second sample of the same coke was later placed in the furnace tube and heated in nitrogen for 2½ hours before determining its reactivity by the same method. Although the value obtained for the percentage of steam decomposed in the second case was slightly lower than that obtained in the first case, there was no evidence that the coke had come to resemble a coke carbonized at 1000° C.

Secondly, the apparatus was somewhat modified and a mixture of steam and nitrogen in constant ratio (3·6 litres

steam; 5·2 litres nitrogen) was passed over a sample of the 500° C. coke, which was heated as rapidly as possible to 1000° C. The issuing gas was sampled and analyzed. Since, if the only reactions occurring are

$$(1)\ C + H_2O \rightarrow CO + H_2$$
$$\text{and } (2)\ C + 2H_2O \rightarrow CO_2 + 2H_2,$$

the volume of hydrogen produced is equal to $(CO + 2CO_2)$, the mean of $(CO + 2CO_2)$ and of H_2 in the sample was taken as the percentage of hydrogen contained, to reduce errors due to analysis, volatile matter, &c. In this way it was found that the ratio $H_2 : N_2$ in the issuing gas remained very nearly constant for 2½ hours—0·57 at the beginning and 0·56 at the end. Consequently it appears that after heating a coke prepared at 500° C. to a temperature of 1000° C. little, if any, change in the reactivity occurs due to maintaining the coke at that temperature. These results are interesting in themselves and as confirming previous experience that our usual method of testing reactivity could be applied (say) at 1000° C. to a coke prepared at a lower temperature by carbonization.

It is not maintained, however, that heating for prolonged periods has no effect on the coke, since it has been demonstrated experimentally that heating a coke prepared at 800° C. for 50 hours at 900 C. considerably reduces its reactivity.

SOME FACTORS INFLUENCING REACTIVITY OF COKE.

I. (*b*). Heat Treatment in Hydrocarbon and Other Gases.

By F. J. DENT and J. W. COBB.

A "pure" coke has been heated in various atmospheres—viz., hydrogen, carbon monoxide, methane, and ethylene—for one hour at different temperatures, and the influence of such treatment on its reactivity towards carbon dioxide observed.

EXPERIMENTAL.

THE APPARATUS.

The apparatus employed was a modification of that used by Branson and Cobb (Gas Research Fellowship Report, 1927) in their investigation of the gasification of various cokes in carbon dioxide, the modification enabling us to treat the coke sample with various gases prior to the determination of its reactivity.

Ten grams of coke, crushed so as to pass through a sieve of ⅛ in. aperture but to remain on one of ⅛ in. aperture, were packed into a tube (Morgan non-porous) 2·2 cms. internal diameter and 57 cms. long. This charge occupied the middle 7 cms. of the tube. A platinum-platinum-rhodium thermocouple, contained in a silica sheath and arranged with its junction at the centre of the coke column, enabled the temperature of the latter to be determined. The remainder of the tube was filled with blocks of the Morgan material in order to reduce the free space, beyond the limits of the coke column, to a minimum. The tube was heated in an electric furnace, which was wound so as to give a constant temperature throughout the length of the coke column. This arrangement is illustrated in fig. 1.

THE EXPERIMENTAL METHOD.

The tube, having been charged with coke, was heated to 900° and maintained at this temperature for one hour; during this period, nitrogen was passed through at a rate of approximately 5 litres per hour. The coke was then brought to the temperature at which it was desired to treat it with the gas under investigation. This gas was then passed over the coke for one hour at a rate of approximately 5 litres per hour, samples of the exit gas being taken over mercury and analyzed in the modified Bone and Wheeler apparatus. The tube was then rapidly swept out with nitrogen, the temperature of the coke brought to 900°, and its reactivity towards carbon dioxide determined at this temperature. This was effected by passing the carbon dioxide through the coke column at a known and constant rate, samples of the exit gas being collected over mercury at specified intervals and subsequently analyzed. The results so obtained were compared with those given by coke which had not undergone the preliminary treatment with the gas.

This procedure was modified in the experiments in which the coke was heated in ethylene, as the decomposition of the gas was in some cases so extensive that it was found necessary to cool the tube and burn off the carbon and tarry matter deposited on the fireclay blocks, &c., before the reactivity of the coke in carbon dioxide could be determined.

The coke used was prepared by carbonizing a Sharlston Wallsend coal (Haigh Moor Seam) containing originally 1·3 p.ct. of ash, carbonization being carried out in small fireclay retorts by the method described in the Gas Research Fellowship Report, 1925. The carbonization temperature was 800° C. and the total carbonizing period six hours.

The carbon dioxide used was obtained from a cylinder, a water seal being employed to maintain a constant head of pressure. The carbon dioxide was freed from oxygen by passing over copper, heated to a very dull redness, and dried with concentrated sulphuric acid and calcium chloride. Its rate of flow was measured by means of an experimental wet meter and regulated by a capillary flow-gauge.

The supply of nitrogen also was obtained from a cylinder, purified by passing over copper heated to a very dull redness and by passing through concentrated sulphuric acid and soda asbestos. Its rate of flow was measured and regulated by means of a calibrated capillary flow-gauge.

The gas, whose action on the coke it was desired to investigate, was contained in a calibrated gasholder, and was purified from carbon dioxide, oxygen, and water vapour with soda asbestos, alkaline pyrogallol, and concentrated sulphuric acid and calcium chloride respectively.

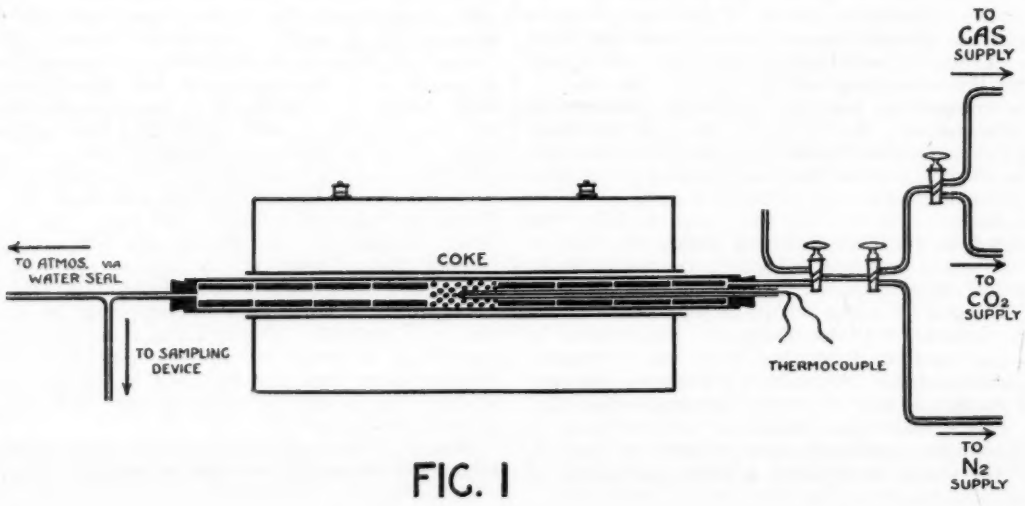
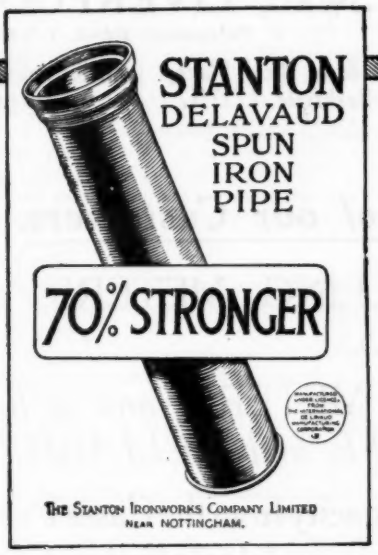


FIG. 1



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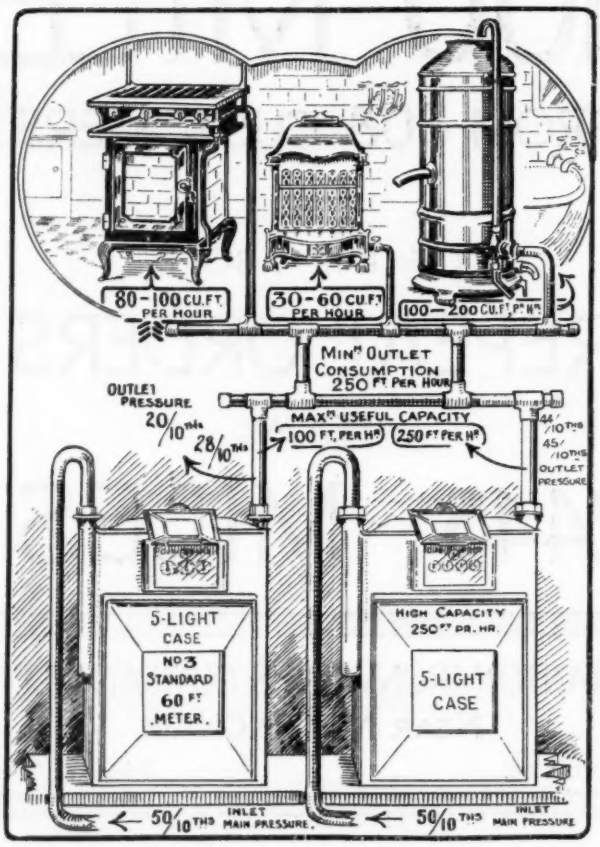
80-100 CU.FT. PER HOUR
30-60 CU.FT. PER HOUR
100-200 CU.FT. PER HR.
MIN.M OUTLET CONSUMPTION 250 FT. PER HOUR
OUTLET PRESSURE 20/10THS 28/10THS
MAX.M USEFUL CAPACITY
100 FT. PER HR.
250 FT. PER HR.
44/10THS 45/10THS OUTLET PRESSURE
5-LIGHT CASE
No 3 STANDARD 60 FT. METER.
HIGH CAPACITY 250 FT. PR. HR.
5-LIGHT CASE
50/10THS INLET MAIN PRESSURE.
50/10THS INLET MAIN PRESSURE

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SAVE ROOM - - LEAKAGE - - MONEY.

Its rate of flow was regulated by means of a capillary flow-gauge.

SOURCES OF THE GASES USED.

(*a*) Hydrogen—from a cylinder (99·4 p.ct. H_2).

(*b*) Methane—from a cylinder. It contained 9 p.ct. of nitrogen.

(*c*) Carbon monoxide—prepared by dehydrating formic acid with sulphuric acid at 170° C. It was given a preliminary purification by passing through chromic acid and soda asbestos. The gas so obtained contained about 98 p.ct. of carbon monoxide.

(*d*) Ethylene—prepared by dehydrating ethyl alcohol with phosphoric acid at 210-230° C. Ether was removed by condensation, and the ethylene further purified by passing through concentrated sulphuric acid and soda asbestos before delivering into the gasholder. The gas obtained was practically pure ethylene.

THE RESULTS OBTAINED.

The effect on the reactivity of the coke of the treatment with various gases is shown in Table III., and diagrammatically in figs. 2, 3, and 4.

Table IV. summarizes results for the period during which the coke was treated with the gas under investigation.

The "free space" between ten grams of coke ($\frac{1}{8}$ in.-$\frac{1}{4}$ in.) packed into the tube as described above was found to be 17·4 cms. This figure was obtained by running alcohol from a burette into a cylinder, closed at one end, of the same diameter as the Morgan tube and containing ten grams of the graded coke. The minimum volume of alcohol required to submerge the coke was taken to be the "free space." This value was employed in the calculation of the "times of contact" given in Table III., where

$$\text{Time of contact in secs.} = \frac{17{\cdot}4}{\text{mean volume in c. of gas passed per second measured at the experimental temperature and pressure.}}$$

The "mean volume" of gas is the average between the volume of gas as it enters the coke column and the volume as it leaves; thus an approximate correction is applied for the increase in volume due to the formation of carbon monoxide.

In experiments 52-57 it is seen that the gas before passing over the coke is admixed with an equal volume of nitrogen; this, in conjunction with an analysis of the exit gas, enabled us to estimate the amount of carbon which has been deposited in the tube and in the coke either as free carbon or dense hydrocarbons. Such calculations have been made, and are recorded in Table IV.

Experiments 43 and 51 were carried out on coke which had been heated in nitrogen at 900° C. for two hours in the first case and one hour in the second. Thus, in comparing the results of experiments 44-47 with 43, and of experiments 52-57 with 51, the differences observed can be said to be due to the action of the gas under investigation, the effect of heat alone having been eliminated.

The cokes used in experiments 43-47 and experiments 51-56 were prepared from the same coal but were carbonized separately; this may account for the slight difference between the reactivities of the cokes in experiments 43 and 51.

THE EFFECT OF HYDROGEN ON CARBON MONOXIDE AT 900° C.

From fig. 2 it can be seen that the treatment of a coke with hydrogen or carbon monoxide leads to a slight reduction in its reactivity, which gradually disappears as the coke is afterwards gasified in CO_2. Both gases appear to have a very similar effect and reduce the average rate of gasification of the coke from 0·23 to 0·19 gram per hour. There were indications that the coke absorbed hydrogen during the initial stages of its treatment with this gas.

THE EFFECT OF METHANE.

The effect on the reactivity of a coke of a preliminary treatment with methane is shown in fig. 3. At 900° C. it is seen that this effect is extensive, compared with the effect of hydrogen or carbon monoxide, but gradually diminishes as the temperature of treatment is reduced, until at 600° the effect is very slight.

At no temperature was the appearance of the coke altered by the treatment with methane, while from Table IV. it is seen that at 800° C. and below this temperature only traces of carbon were deposited on the coke.

In the three cases where samples of the exit gas were taken the amount of methane decomposed during its passage over the coke was very small.

In the Fuel Research Technical Paper No. 18 results are given for the reactivity of various cokes after treatment with methane at 950° C. The authors, Jones, King, and Sinnatt, point out that the reactivity of a coke obtained after this preliminary treatment approximates closely to the reactivity of the same coke after it has been treated with CO_2 for a considerable time.

THE EFFECT OF ETHYLENE.

The effect of ethylene is more pronounced than that of methane and is apparent at lower temperatures. The reduction in reactivity caused by ethylene is more persistent than the corresponding reduction by methane—*e.g.*, at 900° C., after treatment with methane, gasification for

TABLE III.—*Influence on Coke of Pretreatment with Gases.*

Original Weight of Coke, 10 Grams.

Treatment Gas.	Expt. No.	Rate of CO_2 Supply Litres per Hour at N.T.P.	Duration of CO_2 Passage. Hours.	Time of Contact Secs.	Temp. °C.	Temp. of Treatment. °C.	Corrected Percentage of CO in Exit Gas.*									Grs. Coke Gasified.	Average Grs. Coke Gasified per Hour.	Appearance of Coke.
							5 Mins.	15 Mins.	30 Mins.	1 Hour.	1·5 Hours.	2 Hours.	4 Hours.	24 Hours.	52 Hours.			
N_2 .	43	4·73	2	2·8	900	900	..	16·0	17·0	16·8	16·7	16·4	..	..	..	0·46	0·23	..
H_2 .	44	4·73	2	2·9	900	900	..	11·4	12·4	14·0	15·4	16·0	..	..	..	0·38	0·19	..
CH_4.	45	4·69	2	3·0	900	900	..	4·4	4·7	5·5	6·5	6·0	..	..	..	0·14	0·07	Unchanged.
CO .	46	4·68	2	2·9	900	900	..	12·3	12·7	14·2	14·7	16·2	..	..	..	0·38	0·19	..
C_2H_4	47	4·64	52	3·1	900	900	..	3·2	..	..	4·3	..	..	4·4	4·3	2·96	0·057	Considerably lightened in colour.
..	51	5·30	2	2·6	900	..	14·2	13·8	14·3	15·0	15·0	15·1	..	..	..	0·45	0·23	..
CH_4.	52	5·30	2	2·7	900	800	4·6	5·7	6·2	6·95	7·6	8·5	..	..	..	0·20	0·10	Unchanged.
CH_4.	53	5·30	2	2·6	900	700	8·1	9·2	9·9	11·1	11·5	11·7	..	..	..	0·33	0·17	Unchanged.
CH_4.	54	5·20	2	2·6	900	600	12·3	13·2	13·3	13·7	15·4	..	..	..	..	0·41	0·21	Unchanged.
C_2H_4	55	5·32	4	2·7	900	800	4·5	5·5	6·0	6·5	6·8	7·1	8·5	..	..	0·42	0·11	Slightly lightened in colour.
C_2H_4	56	5·35	2	2·6	900	700	5·4	5·8	6·4	7·3	7·9	9·0	..	..	..	0·22	0·11	Unchanged.
C_2H_4	57	5·30	2	2·6	900	600	6·8	7·6	8·3	9·9	10·1	13·5	..	..	..	0·30	0·15	Unchanged.

* Percentage CO corrected for any small amounts of nitrogen present. Times measured from the commencement of the gasification.

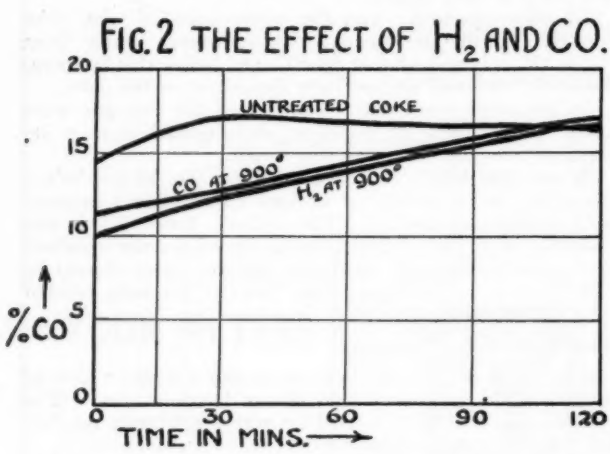
TABLE IV.—*Decomposition of Gases by Hot Coke.*

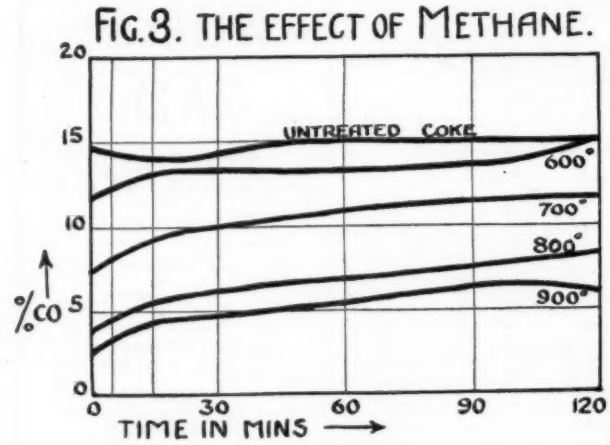
Treatment. Gas.	Expt. No.	Percentage Composition of Mixture Passed over Coke.					Rate of Passage. Litres per Hour at N.T.P.	Time of Passage. Hours.	Percentage Composition of Exit Gas.								Temp. of Treatment. °C.	Grams Carbon Deposited.*
		H_2.	CO.	CH_4.	C_2H_4.	N_2.			H_2.	CH_4.	CO_2.	C_2H_2	C_nH_m.	CO.	C_2H_6.	N_2.	"n" in C_nH_m	
N_2 .	43	..	..	..	..	100	5 appr.	1	..	..	..	..	..	..	..	..	..	900	..
H_2 .	44	99·4	..	..	..	0·6	5 appr.	1	..	..	..	..	..	..	..	..	..	900	..
CH_4.	45	..	..	91	..	9	5 appr.	1	..	..	..	..	..	..	..	..	..	900	..
CO .	46	..	97·6	..	..	2·4	5 appr.	1	..	..	..	..	..	..	..	..	..	900	..
C_2H_4	47	..	..	..	99	·1	5 appr.	1	50·0	36·6	0·2	..	7·6	0·6	3·7	0·7	2·8	900	..
CH_4.	52	0·1	..	49·8	..	50·0	5·84	1	1·2	48·7	0·2	..	..	0·1	..	49·6	..	800	0·0125
CH_4.	53	0·1	..	49·3	..	50·3	5·60	1	0·7	48·5	0·5	..	..	0·3	..	50·1	..	700	Undetectable
CH_4.	54	..	..	50·4	..	49·4	5·79	1	0·1	50·2	0·3	..	..	0·3	..	49·2	..	600	,,
CH_4.	55	..	..	..	49·5	50·5	5·44	1	11·0	11·0	0·9	1·8	23·2	0·4	2·4	49·4	2·3	800	0·693
C_2H_4	56	..	..	..	48·9	51·1	5·63	1	1·3	1·0	0·4	2·2	43·2	..	1·6	50·3	2·02	700	Undetectable
C_2H_4	57	..	..	..	48·0	51·9	5·38	1	0·9	..	0·7	1·2	45	..	0·7	51·5	2·02	600	,,

* Carbon not accounted for in exit gas.

two hours in carbon dioxide led to an appreciable reactivation of the coke, but in the corresponding experiment for ethylene this did not occur to any great extent after CO_2 had passed over the coke for 52 hours, during which period nearly 3 grams of carbon were gasified.

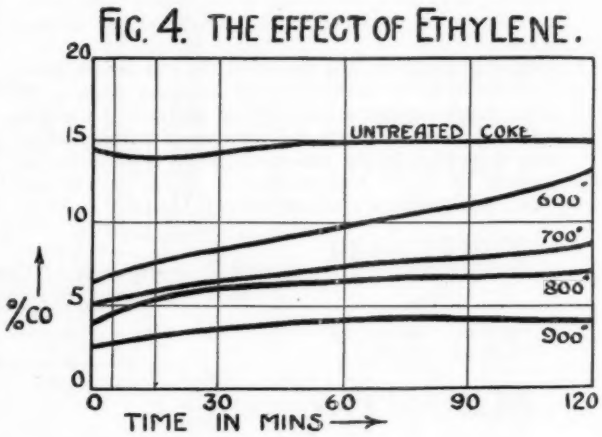
After treatment with ethylene at 900°, the coke had a silvery grey appearance and seemed to be covered with a deposit of the so-called "methane" carbon. "Sooty" carbon was in no experiment deposited on the coke, although it was sometimes deposited on the surface of the tube and blocks. After treatment at 800° the coke was slightly lighter in colour, but treatment at 700° and 600° caused no change in its appearance. As methane was one of the products of decomposition of the ethylene, it might be suggested that the lustrous deposit on the coke obtained in these experiments was due to the secondary decomposition of methane; but the fact that the appearance of the coke was not changed after a pre-treatment with methane, under the same conditions, indicates that the deposit on the coke was not due to this cause. It may be that when a hydrocarbon decomposes homogeneously throughout its bulk the "sooty" form of carbon is deposited, whereas, if it decomposes whilst it is adsorbed on a surface, the carbon is deposited in a hard and lustrous form adhering tenaciously to it. This would explain why, when in contact with an adsorbent substance like coke, ethylene decomposes with the deposition of the co-called "methane" carbon.





From an examination of the compositions of the gases after they have passed over the coke it can be seen that, at the higher temperatures, decomposition of the ethylene was extensive.

At 900° C., the gas as it left the tube had a brown colour and deposited, on a cold surface, tarry matter and crystals with a smell of naphthalene. "Sooty" and "methane" carbon and tarry matter were deposited towards the exit from the Morgan tube. In this experiment, although after the passage of ethylene the tube was swept out with nitrogen, dismantled, and the blocks, &c., heated until the deposits were burnt off, it was noticed that after the temperature was again raised to 900° C. and a stream of carbon dioxide passed over the coke, more naphthalene appeared to be evolved by the coke, and a temporary blockage was caused in the outlet tube. In experiment 55, when the temperature of treatment was 800° C., decomposition of the gas was still comparatively extensive, but the amounts of carbon, tarry matter, and naphthalene deposited were considerably reduced. In experiments 56 and 57 the decomposition of the gas was only slight.



The chief gaseous products of decomposition of ethylene in these experiments appear to be hydrogen, methane, and higher unsaturated hydrocarbons (apparent from the value of "n" given in Table IV.). Small quantities of acetylene and ethane were also detected.

Reviewing the results, it is seen that treatment of a coke with the hydrocarbons methane and ethylene causes a much greater decrease in its reactivity than treatment with hydrogen or carbon monoxide. This reduction occurs even when the hydrocarbon has been decomposed to only a very slight extent, as is apparent from the results of experiments 52 and 56; but the rate at which the coke regains its reactivity during gasification in carbon dioxide appears to depend on the amount of decomposition which the hydro-

carbon has undergone. Compare experiments 45 and 52, 47 and 55.

This investigation is being continued, and the effect of various gases on other properties of the coke, *e.g.*, the ignition point, will be examined.

II.—THE INFLUENCE OF INORGANIC CONSTITUENTS IN THE CARBONIZATION AND GASIFICATION OF COAL.

The Liberation of Sulphur. By J. J. PRIESTLEY and J. W. COBB.

INTRODUCTION AND SUMMARY.

Results reported in previous years under the Gas Research Fellowship (mainly by Monkhouse and Cobb) indicated the importance of atmosphere in the liberation of sulphur compounds from coal during carbonization. In those experiments, for reasons explained, the time of treatment was prolonged, if need be, over several days. We have now made experiments in which coal was carbonized in nitrogen or hydrogen at temperature stages of 100° C. up to 1000° C., maintaining for an hour at each stage and 12½ hours altogether for an experiment, so that the time occupied might come within the range of what is employed in practice. Moreover, since it was realized and stated in the papers previously published that the inorganic constituents present in the coal might have in some respects a marked influence on the results, it was decided to investigate the influence of inorganic constituents on the liberation of sulphuretted hydrogen. For this purpose, the plan already described was adopted of choosing a coal very low in ash, approximately 1 p.ct., and adding to it lime, ferric oxide, and sodium carbonate in an amount (5 p.ct. calculated to oxide) which would ensure in each mixture the dominance of that particular added constituent. The results obtained may be seen in Tables V. and VI. or in the attached figures, 6, 7, 8, 9, where the amounts of sulphuretted hydrogen liberated at each stage of temperature and *up to* each temperature, in both nitrogen and hydrogen, are expressed as percentages of the total sulphur of the coal and plotted for the several mixtures.

TABLE V.—*H_2S Evolved on Carbonization in Nitrogen (S in Coal, 0·89 P.Ct.).*

No. of Experiment.	8 and 9.	11.	13.	15.
Added constit.	*nil*	Na_2CO_3	Fe_2O_3	CaO
"Sulphide" S in coke residue	0·033	0·095	0·488	0·642
Wt. coal charge, grams	20·00	19·99	20·01	20·00
Wt. added constit., grams	*nil*	1·71	1·00	1·00

—	Percentage Sulphur in Coal Evolved as H_2S.							
Temp.	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
°C.								
300	0·1	0·1	0·6	0·6	..	..	..	..
400	12·2	12·3	17·4	18·0	0·8	0·8	0·8	0·8
500	16·4	28·7	20·1	38·1	1·8	2·6	0·9	1·7
600	5·0	33·7	5·3	43·4	0·7	3·3	0·4	2·1
700	3·0	36·7	1·6	45·0	0·9	4·2	0·2	2·3
800	2·7	39·4	2·5	47·5	1·6	5·8	0·2	2·3
900	1·9	41·3	1·4	48·9	1·5	7·3	0·1	2·6
1000	11·1	42·4	0·8	49·7	1·7	9·0	0·3	2·9
Cooling	trace	..	trace	..	trace	..	*nil*	..
Total	42·4	42·4	49·7	49·7	9·0	9·0	2·9	2·9

NOTE.—In "S as H_2S," Col. (1) gives the percentage S as H_2S appearing *at any one stage*. Col. (2) gives the percentage S as H_2S which appeared *up to that stage*.

The results may be summarized as follows:—With the "pure" coal in nitrogen, 42 p.ct. of the sulphur was evolved in heating to 1000° C., 34 p.ct. of which had come off before raising beyond 600° C. Very little was coming off when the heating was finished. The 500° temperature stage was all important, accounting for nearly one-half of the total sulphuretted hydrogen evolved. The sulphur in the coal was present mainly as organic sulphur, as is commonly the case with low ash coals, with a little pyritic sulphur. The results are consistent with the view that both the organic sulphur compounds and the pyrites break down in the lower temperature ranges with the evolution of H_2S and the formation in the residue of more stable compounds which are only slowly decomposed by the further heating at higher temperatures (600° to 1000° C.)

TABLE VI.—*Results in Hydrogen.*

No. of Experiment	18, 20 Mean.	12.	21.	16.
Added constit.	*nil*	Na_2CO_3	Fe_2O_3	CaO
"Sulphide" S in coke residue	0·077	0·084	0·114	0·687
Wt. coal charge, grams	19·99	20·01	20·00	20·02
Wt. added constit., grams	*nil*	1·71	1·00	1·00

—	Percentage Sulphur in Coal Evolved as H_2S.							
Temp.	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
°C.								
300	1·1	1·1	..	..	..	..	..	..
400	14·4	15·5	13·5	13·5	0·3	0·3	0·3	0·3
500	15·4	30·9	19·7	33·0	0·6	0·9	1·0	1·3
600	16·9	47·8	12·0	45·0	2·4	3·3	0·3	1·6
700	13·1	60·9	4·3	49·3	6·3	9·6	0·3	1·9
800	6·7	67·6	1·0	50·3	11·5	21·1	0·2	2·1
900	2·0	69·6	1·1	51·4	21·1	42·2	0·2	2·3
1000	1·3	70·9	1·1	52·5	22·9	65·1	0·4	2·7
Cooling	trace	..	trace	..	6·3	71·4	*nil*	..
Total	70·9	70·9	52·5	52·5	71·4	71·4	2·7	2·7

NOTE.—In "S as H_2S," Col. (1) gives the percentage S as H_2S appearing *at any one stage*. Col. (2) gives the percentage S as H_2S which appeared *up to that stage*.

The "pure" coke in hydrogen shows substantially the same amount of decomposition up to 500° as in nitrogen, but there follows a rapid decomposition at 600° and at later stages which brings the figure up to 68 p.ct. at 1000° C., with the decomposition still continuing. There is here indicated a vigorous attack by hydrogen in the higher temperature ranges on the stable sulphur compounds referred to above as formed by heating at lower temperatures.

The iron oxide mixture in nitrogen evolved little H_2S at any stage, only 9 p.ct. up to 1000° C., showing a (low) maximum rate at 500°. It may be concluded that the decomposition of the coal itself has proceeded substantially as in the "pure" coal experiment, but that the H_2S produced has been absorbed by the added constituent with the formation of a compound stable in nitrogen, presumably ferrous sulphide.

The results in hydrogen are, however, quite different. The stable compound just referred to was plainly decomposed above 500 or 600° C. with increasing rapidity as the temperature rose and the evolution of sulphuretted hydrogen reached 64 p.ct. at 1000° C., rapid decomposition still continuing. This may result from the decomposition of ferrous sulphide in the hydrogen, or, according to Powell, from the handing on of the sulphur from iron to carbon, forming a carbon-sulphur complex decomposed by hydrogen.

The lime mixture evolved very little sulphuretted hydrogen at any stage in either nitrogen or hydrogen. The H_2S evolved by the decomposition of sulphur compounds in the coal was presumably absorbed by lime, and the resulting sulphide was not decomposed either directly or indirectly by hydrogen, so that only 3 p.ct. of the sulphur in the coal was evolved as sulphuretted hydrogen altogether.

The behaviour of the sodium carbonate mixture requires some consideration. Up to 600° C. in nitrogen, with the maximum rate of evolution at 500° C., there was a small but definite increase in the amount of H_2S evolved as compared with the "pure" coal, but above 600° C. the position was reversed. On completing the test at 1000° C., the total quantities evolved were 42 p.ct. for the "pure" coal and 50 p.ct. for the sodium carbonate mixture. In interpreting these results, it is important to bear in mind that sodium carbonate commences to react with carbon, as was demonstrated in another experiment by F. J. Dent, at a temperature near 600°, with the formation of the oxide Na_2O. Above 600°, then, this active oxide absorbs sulphuretted hydrogen, which accounts for the lower evolution of sulphuretted hydrogen above 600° C. of the sodium carbonate mixture as compared with the "pure" coal. It is more difficult to account definitely for the H_2S evolved below 600° being higher than that from the "pure" coal. It must, however, be remembered that from our previous work we know that the low-temperature decomposition of the coal substance generally and the nature of the coke formed are different when sodium carbonate is present. The

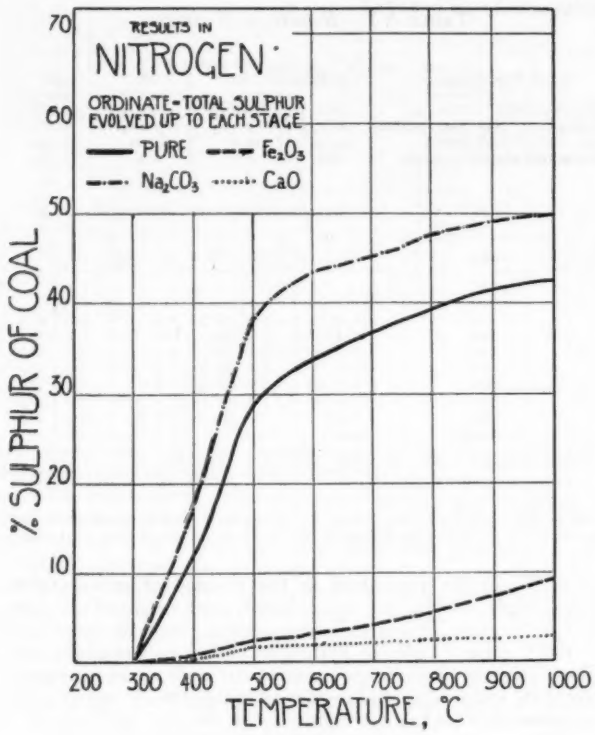


FIG. 6

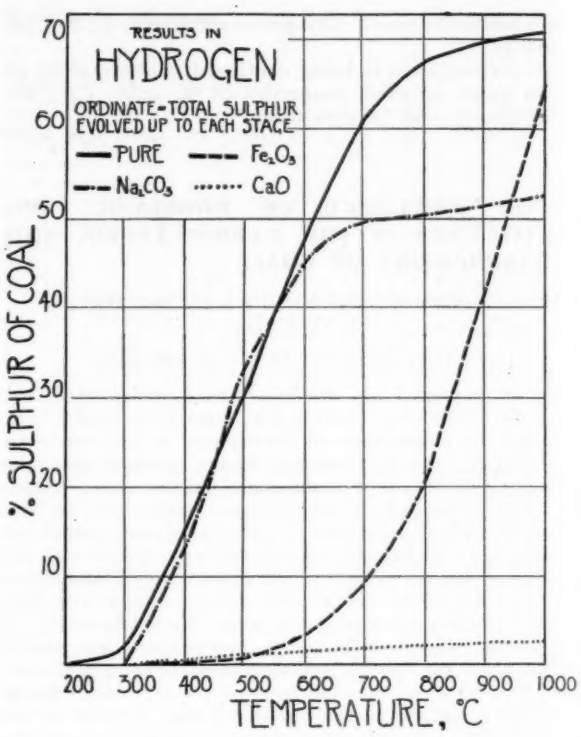


FIG. 7

organic sulphur compounds may well be involved in this phenomenon, whatever its cause, and that may account for the small but definite increase observed in the evolution of sulphuretted hydrogen.

The sodium carbonate mixture in hydrogen displays no marked difference from the " pure " coal until the temperature of 600° C. has been attained, but after that the evolution of sulphuretted hydrogen is much slower than that from " pure " coal, so that at 1000° C. only 52 p.ct. of the sulphur has come off as sulphuretted hydrogen as against 71 p.ct. from " pure " coal. This result is quite comprehensible in the light of the explanation just given. Above 600° C., sodium oxide formed from the carbonate comes into play and retains sulphuretted hydrogen evolved from the coal, by the formation of a stable sodium sulphide. A similar phenomenon is noticed on comparison of the results obtained in these laboratory experiments using lime with those given in the 20th Report of the Gas Investigation Committee on larger scale experiments, in which the carbonate of lime was used. It is there plain that at

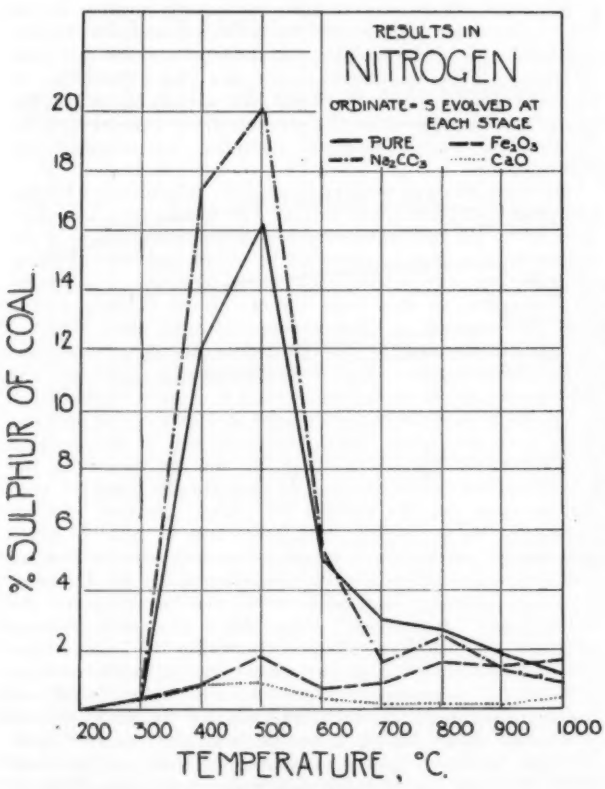


FIG. 8

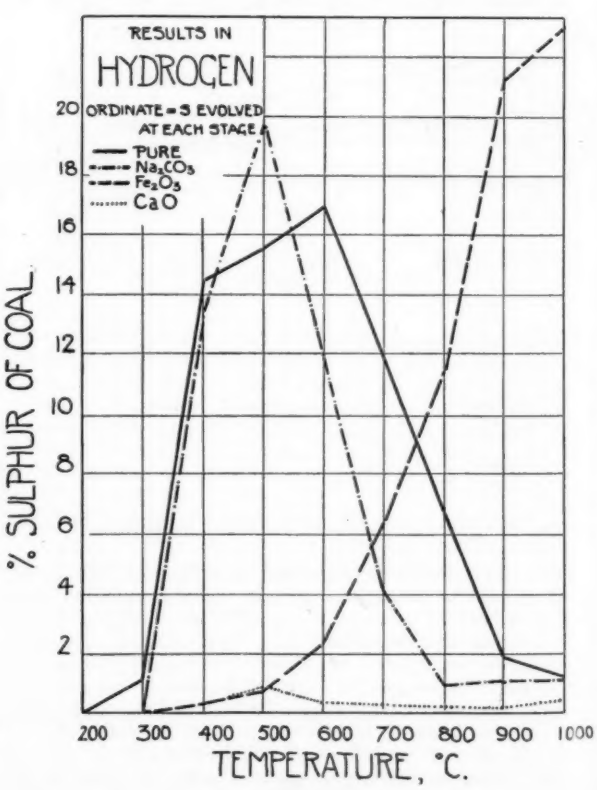


FIG. 9

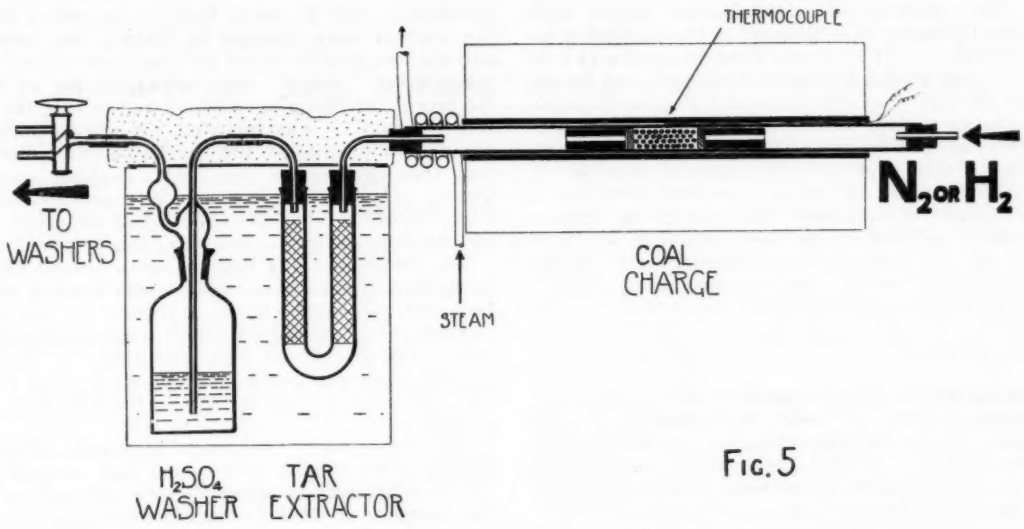


FIG. 5

520° C. the carbonate of lime caused very little diminution in the sulphuretted hydrogen evolved, whereas at 800° C., when the carbonate would have become oxide, the diminution was very marked.

It may be noted that in the laboratory carbonizations described above, carried out in nitrogen, some hydrogen would be added to the gas stream as a result of the decomposition of the coal. This may be calculated as rising from a negligible quantity at the beginning to some 10 p.ct. in the later stages.

The time of contact of the gas stream with the charge is roughly estimated as three seconds, at the mean temperature of 500° C., being, of course, larger at lower and smaller at higher temperatures.

The first appearance of sulphuretted hydrogen, in quantity determinable by the method employed, was at 300° C., becoming much more noticeable at 400° C.

Comparing generally the results with those obtained on a larger scale by the Gas Investigation Committee (20th Report), no inconsistencies are noticeable, but the amounts of sulphuretted hydrogen evolved are lower in the larger scale experiments and the differences as between "pure" coal and mixtures less marked. It would be difficult to trace the quantitative explanation of each of those differences, because the coal used was not the same, the additions of inorganic constituents were not made in the same quantity, the contact of gas stream with solid would be quite different, and the temperature gradient also from time to time and from place to place in the charge. In the laboratory experiments the conditions were so chosen as to be as simple and reproducible as possible.

EXPERIMENTAL.

Preliminary experiments were made with cokes which were prepared at 500° C. by carbonizing the "pure" coal and the coal mixtures in small fireclay retorts heated in a gas-fired muffle furnace for a period of five hours. The experiments showed that at 500° C. the liberation of sulphur as hydrogen sulphide was very sensitive to small changes in temperature. Partly to avoid this difficulty, but mainly for the purpose of obtaining a more complete survey of the influence of the added compounds, the coke experiments were discontinued, and work was begun directly upon coal.

One coal only, Sharlston Wallsend coal (Haigh Moor Seam), was used throughout the series of experiments, specially chosen because of its low ash content. The coal was ground and sieved, the portion passing 30 I.M.M. sieve and retained on 100 I.M.M. sieve being reserved for experiment. The coal was sampled for analysis, the rest being divided into portions. To one portion no addition was made; to others additions of sodium carbonate, iron oxide, and calcium oxide respectively were made, so that each mixture contained an equivalent of 5 p.ct. of the metallic oxide. An analysis of the coal used is given. The method used for the determination of the various forms of sulphur existing in the coal was that of Powell and Parr. It will be seen that the sulphur of the coal was mainly organic.

Analysis of Coal Used.

Proximate Analysis.		*Ultimate Analysis.*	
Ash	0·9	Loss at 105°	1·60
Moisture	1·6	Carbon	82·56
Volatile matter*	36·0	Hydrogen	5·42
Fuel carbon	61·5	Sulphur	0·89
		Nitrogen	1·85
		Ash	0·94
		Oxygen (by diff.)	6·74
	100·0		100·0

* By heating for 7 mins. at approximately 900° C.

Analysis for Forms of Sulphur.

Using the method described by Powell and Parr, Univ. of Illinois Exp. Sta., Bulletin No. 111 (1919).

	P.Ct.
Sulphate sulphur	0·10
Pyritic ,,	0·01
Sulphide ,,	*nil*
Organic ,, (by diff.)	0·78
	0·89

Analysis of Ash (from G.R.F. Report, Marson and Cobb, 1926).

Silica	41·4
Iron oxide	11·3
Aluminium oxide	29·0
Calcium ,,	5·5
Magnesium ,,	1·8
Sulphuric anhydride	4·4
Not estimated	6·6
	100·0

DESCRIPTION OF APPARATUS.

The apparatus was designed to allow a charge of about 20 grams of coal or coal mixture to be heated in a definite manner from 200° C. to 1000° C., while a stream of purified nitrogen or hydrogen was sent through the charge, the hydrogen sulphide evolved being absorbed in cadmium acetate solution.

Nitrogen or hydrogen was taken from a cylinder and, after passing a constant head device, was purified from oxygen by passing through

(*a*) a washer containing alkaline pyrogallate,

(*b*) a tube containing reduced copper gauze heated to redness,

(*c*) a chromous chloride washer (*v.* fig. 5).

Water was removed from the gas by bubbling it through (*d*) concentrated sulphuric acid, followed by (*e*) a calcium chloride tower. Finally the gas was sent through a soda lime tower to remove acid spray and vapour, and a capillary flow gauge, which was used to keep the gas rate constant during an experiment. From this point the gas passed to the furnace tube.

The coal charge was placed in a non-porous Morgan tube, 7 in. internal diameter, which fitted loosely into a tubular electric furnace wound to heat the coal charge uniformly. The charge itself occupied 2½ in. of the tube and was packed fairly tightly into position by two asbestos pads. A Morgan block with a hole drilled through the centre was placed on either side of the

charge. The products of carbonization diluted with the gas used (nitrogen or hydrogen) in the particular experiment passed out of the furnace tube, through a **U** tube packed with glass wool, which served as an efficient tar extractor, and through a washer containing 18 p.ct. sulphuric acid to a two-way tap, furnishing communication with either of two cadmium acetate washers. The tar extractor and acid washer were kept at a temperature of about 80° C. to prevent condensation of water and consequent loss of hydrogen sulphide by solution. The end of the furnace tube was steam jacketed for the same reason. The temperature of the coal charge was measured by a Pt-Pt-Rh. couple situated just outside the tube and directly above the centre of the coal charge.

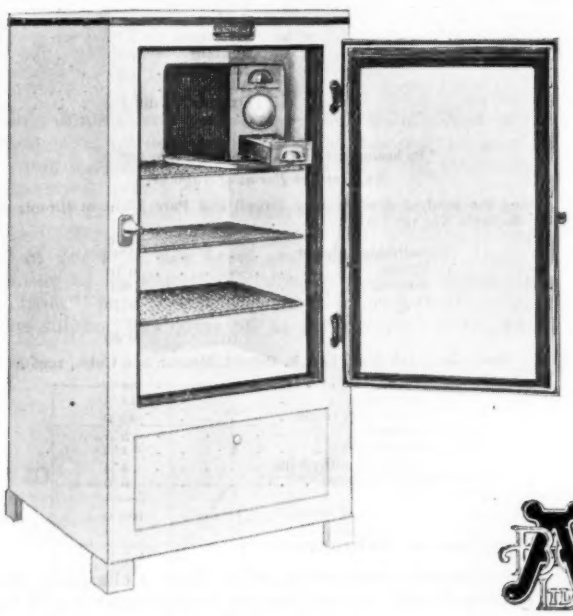
METHOD OF WORKING.

The coal charge was placed in position and the apparatus was evacuated. After all leaks were made good, the apparatus was filled with pure nitrogen or hydrogen and heating commenced. When the furnace temperature reached 200° C., nitrogen or hydrogen was passed at a constant rate of 4·5 litres per hour, and continued for the rest of the experiment. The furnace temperature was kept constant at 200° C. for an hour, at the end of which time the washers were changed by turning the two-way tap, and the temperature raised in 10 minutes to 300° C. This temperature "stage" was maintained for an hour, and the process of changing washers and raising the temperature by 100° C. was repeated. A standard time of 10 minutes was occupied for heating up the furnace from each temperature to the next working stage, 100° higher. Heating in this manner was continued to 1000° C. The current was shut off at the end of the 1000° "stage" and the tube swept out, in every case, by nitrogen.

The contents of the washers were filtered off and the precipitate of cadmium sulphide was washed with dilute ammonia, followed by water, to remove unsaturated hydrocarbons. The cadmium sulphide was estimated iodimetrically. The precipitates were practically free from tar, any present being that which condensed out from the vapour phase by cooling from 80° C. to the temperature of the washers.

The coke, when cool, was removed, weighed, and ground up for analysis. In every case the coke cylinder was found to measure about $\frac{3}{4}$ in. dia., about $\frac{1}{8}$ in. less than the diameter of the tube, due to shrinkage in the later stages of carbonization.

G.J.20-6-28



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REPORT OF THE REFRACTORIES JOINT COMMITTEE.

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W. J. GARDNER, Meltham Silica Firebrick Co., Meltham, near Huddersfield, Yorks.
J. W. MELLOR, D.Sc., Central School of Science and Technology, Stoke-on-Trent (Director of the Research).

REVIEW OF 1927-28 PUBLICATIONS OF THE BRITISH REFRACTORIES RESEARCH ASSOCIATION.

Compiled by A. J. DALE, Technical Secretary of the Association.

Since the 1927 Annual Meeting of the Institution of Gas Engineers, three Bulletins, with original reports given below, have been issued by the Research Association.

Bulletin 15.—July, 1927. (1) "The Manufacture and Properties of Clay-Bonded Silica Bricks, and a Comparison of the Behaviour in Industrial Furnaces of Clay-Bonded and Lime-Bonded Bricks." *W. J. Rees* and *W. Hugill.*

Bulletin 16.—Dec. 1927. (2) "The Experimental Firing of a Scottish Fireclay Material." *A. T. Green* and *A. E. J. Vickers.*

(3) "The Influence of Oxidizing and Reducing Atmospheres on Refractory Materials." Part III. *A. E. J. Vickers.*

*(4) "The Influence of Iron Borate on the Rate of Inversion of Quartz in Silica Bricks." *W. Hugill* and *W. J. Rees.*

*(5) "The Effect of Temperature on the Cracking of Plastic Clay." *S. R. Hind* and *F. Wheeler.*

(6) "Some Effects of Firing Temperature, Kind of Grog and Grading, on the Properties of Firebrick Material." *A. J. Dale.*

Bulletin 17.—*(7) "Second Report on Oil Firing." Parts 1, 2, and 3. *S. R. Hind, H. Oliver,* and *E. O. Mills.*

The present note essays a compilation of those features of the above-mentioned papers which may have a particular interest and value to the Gas Engineers.

Those papers marked with an asterisk have a chief interest to the manufacturer of fireclay and similar goods, and are not considered further herein.*

(1) "A COMPARISON OF THE BEHAVIOUR OF CLAY-BONDED AND LIME-BONDED SILICA BRICKS IN INDUSTRIAL FURNACES"

One object of this investigation by Messrs. Hugill and Rees was to determine whether clay-bonded silica refractories are more resistant to spalling than are silica refractories made in the normal way from crushed quartzitic rocks or ganister, bonded with small additions of lime.

The conclusions formulated by these authors are, with certain modifications, arranged below. Incidentally, it will be observed that some of these findings may have a definite bearing on the preparation and properties of jointing or pointing or patching cements for use on silica retort and combustion chamber masonry.

(1) Clay bonded silica bricks can be made by the same process as ordinary lime bonded bricks. Better and quicker spreading of the clay over the fragments of stone is obtained if the clay "slip" used is deflocculated with sodium silicate. With 3½ p.ct. of ball clay bond, the mechanical properties of green and burned bricks are approximately equivalent to normal bricks with 2 p.ct. lime bond. The general "working" properties of the clay-bond batch are similar to those of a lime-bond batch, except that the clay-bond batch is rather more sensitive to variations in water content.

(2) Under commercial conditions of burning, there is very little difference in the rates of conversion of clay-bond and lime-bond bricks. In other words, other factors constant, the clay-bonded silica brick should not show any greater "after expansion" during industrial service than a lime-bonded product.

(3) The refractoriness of bricks with 3½ p.ct. clay bond is approximately equivalent to that of 2 p.ct. lime-bonded bricks of the same raw material and grading. Subsidence under a load of 50 lbs. per sq. in. commenced at Cone 27 (approx. 1610° C.) with the 3½ p.ct. ball-clay bonded bricks. The general behaviour under load does not appear to differ appreciably from that of 2 p.ct. lime-bonded bricks of the same raw material and grading.

(4) The spalling resistance of clay-bonded bricks is better than that of lime-bonded bricks. This is indicated by the results of large-scale trials at a number of steel works, and particularly by trials at Messrs. Thos. Firth & Sons, Ltd. Laboratory tests by the crude methods of testing for spalling resistance confirmed this characteristic of the clay-bonded bricks.

(5) Where bricks are exposed to slag and corrosive dust, the durability of clay-bonded silica bricks is less than that of lime-bonded bricks—this is particularly the case where the bricks are exposed to basic dust.

In the early stages of their use under such conditions, the wear of the lime-bonded bricks is faster than that of the clay-bonded bricks, but with continued absorption of the slag or dust, there is a reversal, and the clay-bonded bricks are more rapidly corroded than lime-bonded bricks of the same raw material and grading.

(6) In coke ovens, the durability of clay-bonded bricks is indistinguishable from that of normal lime-bonded bricks. The trials indicate that the clay-bonded brick is as resistant to salt corrosion and mechanical wear as lime-bonded bricks of the same grading and heat-treatment.

* An appendix to the Report contained notes on current and unpublished work, which will receive notice in future issues of the "JOURNAL."

(7) The answer to the general question, "Is the clay-bonded silica brick superior to the lime-bonded product for metallurgical purposes?" must be given in the negative. For certain purposes—*e.g.*, electric-furnace roofs—they appear to possess points of superiority. The better spalling resistance of the clay-bonded bricks would make them more suitable for roof-building in the open hearth furnace; and for use on situations where rapid heating or alterations in temperature are unavoidable.

INFLUENCE OF OXIDIZING AND REDUCING ATMOSPHERES ON REFRACTORY MATERIALS. PART III.

In this paper, Mr. A. E. J. Vickers reports further data in support of indications noted in two previous papers. Working with a cone 14 mixture to which various proportions of colloidal ferric hydroxide have been added, he shows:—

(*a*) With this unfired ceramic mixture, the greater the amount of iron present, the greater the effect of a reducing atmosphere on the ordinary refractory test results.

(*b*) The effect of different atmospheres on the refractoriness (as determined in air) is in the following order of increasing magnitude: CO_2, SO_2, CO, H_2, H_2O. A mixture containing 3·7 p.ct. of iron, estimated as Fe_2O_3, softened in an atmosphere of water vapour at a temperature of 1170°, as compared with 1400° C. in an atmosphere of oxygen.

The practical significance of these findings is now being investigated by Mr. H. T. S. Swallow.

THE EXPERIMENTAL FIRING OF A SCOTTISH FIRECLAY MATERIAL.

Messrs. A. T. GREEN and A. E. J. VICKERS.

In connection with refractory materials, it is becoming increasingly understood that the properties and industrial capabilities of the finished products are, to no small extent, conditioned by the methods of manufacture, and in particular by the nature and severity of the kiln treatment. The work recorded in this paper by Messrs. Green and Vickers was originally designed to determine the maximum safe rate of firing refractories made from a typical Scottish fireclay mixture.

Referring to ordinary 9 in. brick sizes, the authors were able to state that an experimental firing of 28½ hours up to a maximum temperature of 1450° C., gave an entirely satisfactory product as compared with the finished bricks from the normal industrial firing of 45 to 53½ hours. It is, however, pointed out in the report that the experimental kiln is much smaller than the works kiln; and, further, that in some positions, mainly near the burners, the rate of heating was too rapid and warped, and other unsatisfactory samples were obtained.

Such data may later result in a direct economic benefit to the users of refractory materials.

SOME EFFECTS OF FIRING TEMPERATURE, KIND OF GROG AND GRADING, ON THE PROPERTIES OF FIREBRICK MATERIAL.

A. J. DALE.

In this work, the author directs attention to the industrial field for special refractories, in view of the fact that no matter what type of furnace one considers, it is apparent that some portions of the structure suffer a maximum deterioration.

Various special grogs, in coarse and fine gradings, were accordingly bonded with a standard plastic clay and subjected to a low temperature and high temperature heat treatment respectively.

All these fired products were then tested for (*a*) Ordinary Refractoriness; (*b*) Refractoriness under load, using the modified Mellor and Moore load test; (*c*) After-contraction after repeated heat treatments at Cone 14 for two hours.

A consideration of the tabulated data focusses attention on the potential value of high alumina refractories for use in those locations of retort settings which may be susceptible to (*a*) Spalling or surface flaking; (*b*) Corrosion or erosion by solid, liquid, or gaseous compounds containing much iron.

Both aloxite (fused alumina) and calcined diaspore (hydrated alumina) were used as grogs, and it is noteworthy that the clay-bonded refractories containing these materials showed a continued expansion—not contraction—on refiring for three times at Cone 14 down. An exception was the coarse-grained diaspore refractory which showed an after-expansion during the second refire, and an after-contraction during the first and third refires.

All the aluminous refractories gave an ordinary refractory test result of Cone 35 or greater.

Mr. JNO. P. LEATHER (Chairman of the Committee), presenting the report, said: I should have liked to spend some time upon this report, because I do not think the members as a whole pay sufficiently close attention to this important question. Reference was made in last year's report to the financial position of the British Refractories Research Association, and the reduction in the research grant. A considerable amount of research has been done, however, during the year, as shown in the present report. First you will find a review of the publications of the Refractories Research Association, and, secondly, there is a special communication on the thermal insulation of carbonizing plant. The first of these indicates in summarized form the results of researches more or less directly affecting the gas industry carried out during the year. During the year the Committee have given further consideration to the clauses in the Standard Specification dealing with the test for the after-expansion of silica material, and a report was prepared for the Committee on that question; but when it was considered, it was felt that further work was desirable before publishing anything definite or coming to any agreement as to modification of the tests prescribed. Much consideration has been given by the Council of the Research Association—on which Mr. Price and myself represent the Institution—as to the raising of funds; and many gas undertakings have responded to the Association's appeal, so that it is hoped that with an increased grant the amount of research work may be increased in the coming year. The Committee have requested the Association to investigate and report upon the most suitable materials for jointing firebrick and silica brick, and also on the cements to be used for the hot patching of retorts—two questions about which we have received special inquiries from engineers. There is much of interest in the Report. The greater portion deals with the question of insulation, and the conclusion is that it is certainly worth while to insulate retort settings. The loss of heat, especially from the metal work of a setting, is very high; and in that connection it is interesting to note that a considerable loss of heat has been found in some cases where metal sight-hole doors are used. It is very small, of course, much smaller than that from the metal of the retort mouthpiece, but it is an important part of the loss from the outside of the setting. Mr. Carr suggested that I should mention that there is no necessity to go to any very great trouble in getting a useful sight-hole block, because it would be possible in a few minutes to make, as his foreman has done, a good sight-hole block with a Moler brick, and which one can put in and take out with one's hands, showing that it is not very hot, and, therefore, that there is not very much loss by radiation and convection. The report shows definitely that it is advisable to design your settings with a view to insulation, and not just to think of insulation as an afterthought, and imagine that, after making your ordinary setting, you can put some insulating material over the top and get rid of your troubles in that way. The report shows that such methods do not produce anything like such good results as are produced by a well-conceived scheme, with pre-conceived disposition of insulating materials based on an appreciation of their properties, the behaviour of the refractories in the setting, and the behaviour and peculiarities of the plant. To put an insulation blanketing in the setting is to increase the temperature to which the firebrick walls are subjected. That is an important thing to remember. On the other hand, of course, you are reducing the temperature on the outside, from which the radiation and convection takes place. I will simply commend the other portions of the report to the careful consideration of the members, and add that the Committee will always be glad to receive requests or any communications from members of the Institution with reference to any difficulties relating to refractory materials which they may encounter in their work. I think that frequently engineers in the smaller works—I do not say those in the large works—when they have trouble with refractory material make up their minds not to obtain material from the same firm again. The trouble, however, might not be due to the fault of the firm supplying the material; and if the matter is brought to the notice of the Refractory Materials Research Committee and the Research Association, we shall be very glad to send anyone down to a works to give advice, which advice possibly will be of great advantage to the engineers concerned. I hope that not only will you support the work of the Committee by asking us for help, but also that you will help us financially, so that the research will not suffer.

The PRESIDENT: On behalf of the meeting I should like to

thank Mr. Leather for the manner in which he has presented this report. One important point he has called to our notice is that of heat loss. The industry as a whole is realizing what can be done, by economizing heat, to reduce the prices of our commodities. The other matter I would commend to your attention is that relating to funds for research work. Behind all the reports we have had this morning there is that appeal for research; and I do urge that you will support this refractory materials research financially.

Lieut.-Col. W. M. CARR, M.C. (Stretford): I should like at this juncture to ask a question. Many of us would like a lead from the Council in the matter of contributions to the British Refractories Research Association. Some of us are subscribing towards this research work, and it would be very helpful if we had a lead. I admit that possibly some of us are making more use of the services of the officials—I speak now particularly of Mr. Dale and his assistants—so far as our refractory materials investigations go. The enormous importance of this work is appreciated by everybody, and it helps us in the investigations we can carry out ourselves. My own work is so extremely limited that I am obliged, if I am to get satisfactory results, to make use of the machinery of the Research Association.

The PRESIDENT: The Council of the Institution have subscribed £250 towards this work, and many of the companies are giving intermediary subscriptions. You might ask why we do not give more, but we can only cut our coat according to our cloth. I wish we had more funds, but the Council have subscribed, and have commended the matter to the National Gas Council and other organizations and undertakings who might be willing to subscribe to the funds.

Mr. LEATHER: I have not all the information here, but a number of gas companies and municipal undertakings have, as I have mentioned, responded to the appeal of the Association. After all, £250 a year, though it is a good contribution from the Institution's funds, is not sufficient to keep one research worker going; and we want at least one, if not two, research workers on gas work only. We are hoping that when trade is better we might perhaps obtain further contributions from the steel industry. At present, apart from the gas side, the most important contribution is from the makers of refractory materials who benefit by the work of the Association. If the steel industry provides us with a considerable sum of money, it will also expect that some of the staff will be concentrated upon problems connected with that industry. A problem which affects the steel industry, however, might also affect the gas industry to some extent. If we have sufficient money, we shall have two research workers practically entirely engaged upon problems in which the gas industry is particularly interested. We are hoping that there will be a still greater number of gas companies and municipal undertakings than at present making contributions of £10, £15, £25, or more per annum. The minimum contribution to the Research Association is £5 5s., but that does not go very far.

BRITISH ENGINEERING STANDARDS ASSOCIATION—SECTIONAL COMMITTEE 45—COAL.

COAL ANALYSIS AND SAMPLING COMMITTEE.

APPOINTMENT AND CONSTITUTION OF COMMITTEE.

The SECRETARY reported that the Main Committee of the B.E.S.A. at their last meeting had unanimously approved the recommendations of the Conference held on Oct. 25, 1927, and had authorized the formation of this Sectional Committee.

In order to secure as complete a representation of the industry as possible, whilst still keeping the numbers within practical limits, the invitations to nominate to the Committee had been divided into four groups—namely, the producers, the users, the exporters, and the technical institutes directly interested in the subject, as shown in C.B. (OC) 3929. From each of these groups fourteen representatives were invited.

The constitution was read, and the Committee considered it fully representative.

CHAIRMAN'S REMARKS.

Mr. MAURICE WILSON, Chairman of the Main Committee welcomed those present in the name of his colleagues, and explained that a Sectional Committee of the B.E.S.A., once constituted, had practical autonomy in carrying out the work referred to it, and would have to decide upon its general course of action. As Chairman of the Main Committee he was glad to be able to assist this Committee at the commencement of its work. The Conference, he said, had shown quite clearly that the representatives of the trade, as distinct from the purely scientific men, considered that the question of sampling was of equal importance with the question of analysis. The business of the meeting was to arrange matters so that the wishes of the Conference might be carried forward successfully without delay. As Chairman, he might perhaps be allowed to make one or two general suggestions.

The subject appeared to divide itself into the two main branches of sampling and analysis. It seemed desirable that any Sub-Committees appointed to consider these matters should consist of members specially selected for their practical experience. If he had correctly interpreted the feeling of the Conference, the industrial members would seem to have laid particular stress upon the importance of the commercial aspect as distinct from the purely scientific. He felt, therefore, that in order to fulfil the wishes of the industry as expressed at the Conference, it was essential to prepare with the least possible delay suggestions for standard commercial methods of sampling and analysis which would be acceptable not only in this country, but also abroad.

A question was raised as to the relationship between the B.E.S.A. and the Fuel Research Board. In reply, the SECRETARY pointed out that the problem on which the Committee was now engaged was the result of a direct request from the Department of Scientific and Industrial Research to the B.E.S.A., inviting them to undertake the work of securing national agreement on these important questions of industrial standardization in the coal industry.

Dr. Lander had explained at the Conference that one of the reasons which had led the D.S.I.R. to approach the B.E.S.A. was the tendency for buyers to look upon the Fuel Research Board publication as a national British standard, whereas it was only intended for the specific survey they were undertaking, and was not necessarily suitable for commercial purposes.

Mr. SINNATT, representing Dr. Lander, added in support of this statement that the whole of the very considerable amount of information which had been collected by the Fuel Research Board during the past few years, on the subjects of sampling and analysis, would be at the disposal of the B.E.S.A. Committees.

After some further discussion, it was unanimously agreed to appoint two Sub-Committees, *ad hoc*, one for sampling and the other for analysis, and that the commercial aspect should be kept well in mind throughout.

It was also agreed that the Sub-Committee on Sampling should divide itself into two Panels—one to study the home trade, and the other the export trade.

It was decided to invite the following to accept seats on the Sub-Committee on Sampling:

SUB-COMMITTEE 45/1—SAMPLING.

Name.	*Address.*
Mr. T. H. Adams,	Divisional Chemist, L.M.S. Rly. Co., Derby
Major F. J. Bywater,	South Metropolitan Gas Co., Newcastle-on-Tyne
Mr. C. L. Clay,	Merthyr House, James Street, Cardiff
Mr. L. Davies,	Consulting Chemist, Cardiff
Mr. J. H. Duncan,	Consulting Chemist, Cardiff
Dr. J. J. Fox,	Government Laboratory, London
Prof. Thomas Gray,	Royal Technical College, Glasgow
Mr. W. R. Hann,	Powell Duffryn Steam Coal Co., Ltd., Cardiff

SUB-COMMITTEE 45/1—SAMPLING.—(*Continued.*)

Mr. G. A. Hebden,	Rawmarsh, near Rotherham
Mr. H. Hollings,	Gas Light and Coke Co., London
Mr. G. N. Huntley,	Consulting Chemist, London
Dr. J. G. King,	H. M. Fuel Research Station, Greenwich
Dr. R. Lessing,	Consulting Chemist, London
Dr. A. Michie,	Consulting Chemist, Newcastle-on-Tyne
Mr. A. R. Miles,	A. R. Miles & Co., Ltd., London
Mr. W. M. Miles,	Chief Chemist, Electricity Department, Sheffield
Mr. A. B. Owles,	Chief Chemist, Electricity Department, Manchester
Mr. B. Samuels,	Babcock & Wilcox, Ltd., London
Mr. C. A. Seyler,	Public Analyst, Swansea

It was decided to invite the following to accept seats on the Sub-Committee on Analysis:

SUB-COMMITTEE 45/2—ANALYSIS.

Mr. T. H. Adams,	Divisional Chemist, L.M.S. Rly. Co., Derby
Prof. W. A. Bone,	"Montrose," St. Albans, Herts.
Prof. John W. Cobb	Fuel Department, University, Leeds
Mr. L. Davies,	Consulting Chemist, Cardiff
Mr. J. H. Duncan,	Consulting Chemist, Cardiff
Mr. J. T. Dunn,	Public Analyst, Newcastle-on-Tyne
Mr. S. E. Fedden,	Electric Supply Department, Sheffield
Mr. C. P. Finn,	Consulting Chemist, Wath-upon-Dearne, Yorks.
Dr. J. J. Fox,	Government Laboratory, London
Mr. G. N. Huntley,	Consulting Chemist, London
Dr. S. Roy Illingworth,	Bryn Fedwen, Radyr, near Cardiff
Dr. J. G. King,	H.M. Fuel Research Station, Greenwich
Dr. R. Lessing,	Consulting Chemist, London
Mr. A. R. Miles,	A. R. Miles & Co., Ltd., London
Dr. H. Peile,	Priestman Colliery Ltd., Newcastle-on-Tyne
Mr. T. F. E. Rhead,	Chief Chemist, Gas-Works, Birmingham
Mr. B. Samuels,	Babcock & Wilcox, Ltd., London
Mr. L. H. Sensicle,	Newcastle and Gateshead Gas Co.
Mr. C. A. Seyler,	Public Analyst, Swansea
Mr. W. J. Smith,	Gas Offices, Corporation of Bolton
Mr. F. S. Sinnatt,	D.S.I.R., London
Prof. R. V. Wheeler,	The University, Sheffield

It was agreed that these Sub-Committees should have power to co-opt additional members if necessary.

INTERNATIONAL AGREEMENT.

In view of the paramount importance of securing the agreement of the foreign purchaser of British coal to whatever was ultimately recommended for adoption in this country, the question as to the procedure to be adopted to secure this was briefly considered.

The Secretary said that the B.E.S.A. was in close touch with the national standardizing bodies in other countries, but he thought that the Committee might prefer that in the first instance, at any rate, a liaison Committee should be appointed to consider in detail this very important aspect of the problem, and make suggestions as to the exact procedure which should be adopted in regard thereto.

The Committee entirely agreed with this proposal, and it was suggested that rather than appoint a Committee at the moment, each of the Sub-Committees should take the matter into consideration and nominate three or four members to constitute such an international liaison Committee. The Committee would then meet and submit its proposals to the Sectional Committee.

In view of the previous experience of the B.E.S.A. in international work, attention was called to the necessity for the preparation of definite British proposals before the commencement of any actual attempt to secure international agreement.

This concluded the official business of the meeting. The Secretary, however, desired to refer to the question of the direct co operation of the coal-owners in the various districts. Mr. Mitton, who was present, was Deputy-Chairman of the B.E.S.A. Sectional Committee on Colliery Requisites, and expressed the hope that the coal owners in the districts would have ample opportunity of going into the different proposals put forward by the Committees. The Secretary thought that the six or seven Regional Committees already appointed to assist the B.E.S.A. in the Colliery Requisites might be called in to assist them in this problem also. The Committee agreed, and Mr. Mitton, who was entirely in favour of the proposal, kindly consented to put the suggestion forward.

The question of including the subject of the sampling and analysis of patent fuels and also of coke was brought forward, and after a brief discussion the Committee decided to ask the Sub-Committees to take this into consideration in their deliberations.

After a vote of thanks to the Chairman, the meeting adjourned.

NOMINATIONS FOR SECTIONAL COMMITTEE 45—COAL.

Name.	*Representing.*
Capt. J. H. Harrison,	Admiralty
Mr. J. H. Duncan,	Crown Agents for the Colonies
Mr. Wallace Thorneycroft, Mr. James Robertson, Mr. N. Forrest, Mr. Ridley Warham, J.P., Dr. Peile, Mr. W. R. Hann, M. J. Brass, Mr. Robert Clive, Mr. Llew. Davies, Mr. H. Eustace Mitton, Mr. R. Landless, Mr. J. J. Joynes, Mr. W. D. Lloyd,	Mining Association of Great Britain
Mr. H. W. Cole, C.B.E.,	Mines Department
Mr. A. H. Tissingham,	Federation of British Industries
Mr. G. W. Andrew,	Federation of British Industries
Dr. C. H. Lander,	Department of Scientific and Industrial Research
Prof. Thomas Gray,	Department of Scientific and Industrial Research
Mr. R. A. Miles,	London Chamber of Commerce
Mr. E. C. Evans,	National Federation of Iron and Steel Manufacturers (representing the Pig Iron Industry)
Sir Richard A. S. Redmayne, K.C.B.,	The Institution of Civil Engineers
Mr. C. M. Croft,	The Institution of Gas Engineers
Mr. W. J. Smith, B.Sc.,	The Institution of Gas Engineers
Mr. W. M. Selvey,	The Institution of Electrical Engineers
Mr. H. N. Gresley, C.B.E.,	The Institution of Mechanical Engineers
Mr. B. Samuels,	The Institution of Mechanical Engineers
Dr. R. V. Wheeler,	The Institution of Mining Engineers
Mr. Clarence A. Seyler,	The South Wales Institute of Engineers

NOMINATIONS FOR SECTIONAL COMMITTEE 45—COAL (*Continued*).

Name.	*Rebresenting.*
Dr. S. Roy Illingworth,	The South Wales Institute of Engineers
Dr. R. Lessing,	The Institute of Fuel
Mr. T. F. E. Rhead,	Society of Chemical Industry
Mr. E. V. Evans,	Society of Chemical Industry
Mr. C. B. Collett,	Rly. Companies of Great Britain
Mr. T. H. Adams,	Rly. Companies of Great Britain
Sir Walter Raine, M.P.,	British Coal Exporters' Federation
Mr. C. L. Clay,	British Coal Exporters' Federation
Mr. R. Ratcliffe Steel,	London Coal Exporters' Association
Mr. John Harrison,	London Coal Exporters' Association
Mr. G. A. Hebden,	Coke Oven Managers' Association
Mr. J. T. Richardson,	The National Council of Coal Traders
Mr. John Charrington, jun.,	Coal Merchants Federations of Great Britain
Mr. L. H. Sensicle,	The National Gas Council
Mr. H. Hollings.	The National Gas Council
Mr. S. E. Fedden,	Incorporated Municipal Electrical Association.

Mr. W. J. SMITH (Delegate of the Institution), presenting the report, said: In response to an official request from the Committee of the Privy Council on Scientific and Industrial Research, the main Committee of the "B.E.S.A." authorized the holding of a fully representative conference to ascertain whether there is a general concensus of opinion favourable to the adoption of Report No. 7, "Methods of Analysis of Coal," as drawn up by the Fuel Research Board, as a basis for the preparation of a British Standard Specification for national use. The Committee of the Privy Council state that the question of methods of analysis is one of increasing importance owing to the growing tendency to purchase coal to specification. Invitations to nominate representatives were sent out to four groups—namely, the producers, the users, the exporters, and the technical institutes directly interested in the subject—each group to nominate fourteen representatives. Messrs. H. Hollings and L. H. Sensicle were elected to act on behalf of the National Gas Council, and Messrs. C. M. Croft and W. J. Smith on behalf of the Institution of Gas Engineers.

A conference was held on Oct. 25, 1927, when it was unanimously agreed that such a national specification was desirable. The main Committee of the "B.E.S.A." approved of this finding, and authorized the formation of a sectional Committee to deal with the matter. The Conference was of opinion that, while Report No. 7 of the Fuel Research Board might be quite satisfactory from the standpoint of research, some modification would be required to make it suitable as a national specification.

Two main points were raised at the Conference. The first of these was that a national specification for analysis of coal was of no value unless it included a standard method of sampling; and the second was that such methods of analysis should be selected with due regard to the commercial side of the subject. Two sub-committees were accordingly set up. One was to deal with the sampling and the other with the analysis. In my opinion the Committees are fully representative. The interests of the gas undertakings are being watched on the Sampling Sub-Committee by Mr. H. Hollings, of the Gas Light and Coke Company, and on the Analysis Sub-Committee by Mr. T. F. E. Rhead, Gas-Works, Birmingham, Mr. L. H. Sensicle, Newcastle and Gateshead Gas Company, and Mr. W. J. Smith, Gas-Works, Bolton. It is gratifying to note that the whole of the work of the Fuel Research Board connected with Report No. 7 has been placed at the disposal of the Sub-Committee.

Several meetings have been held, and the work is proceeding favourably. The scope of the investigation has been extended to include coke and patent fuels. Judging from the enthusiasm which has been shown at the various meetings, I have reason to anticipate that the results of the inquiry will be of great value to the gas industry.

The PRESIDENT moved the adoption of the report.

Mr. JOHN TERRACE seconded.

Mr. T. F. E. RHEAD (Birmingham): It would be extremely helpful to our representatives on the Committee if gas engineers and gas chemists who have any particular ideas on this matter would send them along to one or other of the representatives. Mr. Smith has represented the Institution, and I personally represent the Society of Chemical Industry as well as the Institution on both Committees. If engineers will send any ideas they may have to Mr. Smith, Mr. Sensicle, or myself, they would help us very much, because the question is a most difficult one to tackle. I personally did not realize how great were the troubles until we got into Committee and were up against the difficulties of sampling for the export trade. I knew the difficulties were great, but I did not realize that the matter was so extremely complicated as it is.

The report was adopted.

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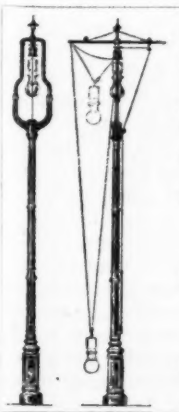

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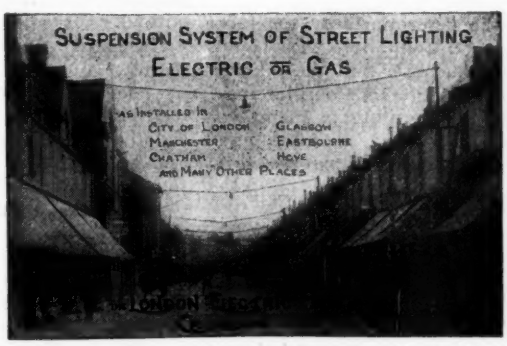

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INTERNATIONAL COMMISSION ON ILLUMINATION.

MEETING OF TECHNICAL COMMITTEE AT BELLAGIO.

Report by Mr. ROBERT WATSON, of Doncaster, Delegate of the Institution.

Meetings of the Executive and Technical Committees of the Commission were held at Bellagio on Aug. 31, and Sept. 1, 2, and 3, 1927, for the purpose of expediting the work delegated to them at the Geneva Conference and in preparation for the plenary congress of the major body. The delegates present were :—

Italy.—MM. Bordoni, C. Montu, Ferrario, E. Sospisio, G. Via, G. Bisazza, M. Bohm, C. Clerici, S. Danesi, M. Muggia, L. Pello, G. Peri, C. Puccioni, G. Sartori, and E. Vianello.

Great Britain: Mr. H. Buckley, of the National Physical Laboratory, Teddington; Mr. W. Bush, of the E.L.M.A. Lighting Service Bureau, London; Lt.-Col. K. Edgcumbe, Vice-President of the Commission; Mr. L. Gaster, Hon. Secretary of the Illuminating Engineering Society, London; Mr. P. Good, of the Institution of Electrical Engineers; Mr. L. B. W. Jolley, of the General Electric Company, Ltd., Wembley; Mr. J. Macintyre, of H.M. Office of Works; Mr. C. C. Paterson, President of the Commission, Director of the Research Laboratories of the General Electric Company, Ltd., Wembley; Dr. E. H. Rayner, of the National Physical Laboratory, Teddington; Dr. J. W. T. Walsh, of the National Physical Laboratory, Teddington, General Secretary of the Commission; Mr. R. Watson, of The Institution of Gas Engineers; Mr. E. Willis, of the Institution of Municipal and County Engineers.

France.—MM. J. Chappuis, P. Janet, Blondin, Jouaust, Leblanc, Maisonneuve, Wetzel, Imbs, Sartre, De Valbreuze, P. Fleury, F. Cellerier, M. Bailly, and M. Gouffe.

Germany.—MM. Meyer, Block, Dziobek, Pirani, Wissmann, Teichmuller, and Gehrcke.

Switzerland.—MM. Joye, A. Filloil, E. Payet, F. Largiader, W. Trub, E. Tobler, and Ed. Binkert.

U.S.A.—Messrs. E. P. Hyde, C. H. Sharp, F. Meyer, A. E. Kenelly, L. M. Marks, and S. G. Rhodes.

Austria—MM. Koch and Kremenczky.

Japan.—M. Kan Tanaka.

Holland.—MM. Halbertsma and Feldman.

Belgium.—M. M. Vink.

International Bureau of Labour.—Dr. Carozzi.

U.S.S.R.—M. Chatelain (as observer).

OFFICERS OF THE COMMISSION.

The officers of the Commission were : Dr. Hyde (President); Col. Edgcumbe, M. Rouland, and Sig. Semanza (Vice-Presidents); Mr. C. C. Paterson (Hon. Secretary and Treasurer); and Dr. J. W. T. Walsh (General Secretary). M. Rouland was unable to be present. Sig. Semanza could not, through illness, attend the meetings, but happily found himself able to put in an appearance at the last meeting of the delegates.

The place of the meeting was determined by the fact that many members of the National Committee were to be in attendance there for another purpose, and the opportunity was thus afforded both for a conference on illumination matters and for the early collaboration of members of the Committees of Belgium, Germany, Holland, and Japan which had joined the Commission since the last plenary session at Geneva in July, 1924.

The meetings held under the presidency of Dr. E. P. Hyde (U.S.A.) were well attended, the number of delegates present being nearly 70. Representation was obtained from the following countries : Austria, Belgium, France, Germany, Great Britain, Holland, Italy, Japan, Switzerland, Union of Soviet Socialist Republics, United States of America, and also from the International Labour Department of the League of Nations. There were twelve delegates from Great Britain representing the National Physical Laboratory (Teddington), The Institution of Gas Engineers, the Institution of Electrical Engineers, and other electrical interests, the Illuminating Engineering Society, the Institution of Municipal and County Engineers, and H.M. Office of Works.

The keen interest in the proceedings was indicated by the number and variety of reports and papers presented, covering ground, however, which it was impossible in the four days available adequately to traverse. Nevertheless progress was made in the consideration of matters which had been delegated to the technical Sub-Committees, and the points of view of the National Committees ascertained, eased the work to be undertaken by the Commission at the plenary congress to be held in New York next September, at which I have had the honour of being appointed by the Council to represent The Institution of Gas Engineers.

The subjects which particularly occupied the attention of the Sub-Committees at Bellagio were factory and school lighting; illumination definitions and symbols; heterochromatic photometry; colorimetry; automobile headlights; and vocabulary.

Proposals were submitted at the general meetings of the delegates for the furtherance of the objects of the Commission with suggestions as to the methods whereby they could best be achieved.

The U.S.A. members presented a tentative list of topics for consideration by the National Committee before the forthcoming plenary session at New York. It was felt, however, that the programme outlined was too great for that purpose, and as there were subjects which required more immediate study, the Executive Committee advised the reference of specific matters to definite National Committees which might in the capacity of secretariats undertake consideration of these, collaborating with and collecting from the other countries information connected therewith. The Secretariat Committees would thus bring their particular subjects as far as possible to the point of international agreement for ultimate submission at the plenary session.

The previous method had been to appoint Sub-Committees consisting of one or more members from each country to deal with specific matters.

The proposal of the Executive Committee was accepted, and a programme of work was adopted.

The subjects selected and delegated were as follows: Vocabulary (Switzerland); Definitions and Symbols and Heterochromatic Photometry (France); Automobile Headlights and Factory and School Lighting (U.S.A.); Street Lighting and Diffusing Materials (Germany); Daylight Illumination and Signal Glasses (Great Britain); Photometric Test Plates (Austria); Photometric Accuracy (Holland); Light Flux Distribution (Belgium); Fundamental Research on Glare (Italy); Cinema Lighting (Japan); Colorimetry (awaiting report from present Committee).

Although subjects have been specifically allocated to various countries, the National Committees are keeping in touch with the general programme, and it may be mentioned as an example that the British Engineering Standards Association Street Lighting Committee are in respect to this specification in active collaboration with the Secretariat of Germany.

In addition to the twenty-five contributions considered by the Technical Committees, no fewer than twenty-one reports, specifications, and papers were submitted at the two general meetings of the delegates. These covered such diverse subjects as primary standards of light, methods of lighting, street lighting, portable photometers, industrial reflectors, tungsten filament lamps, diffusing glassware, glare, and the like.

At the final conference, Dr. Hyde, the retiring President announced that Mr. C. C. Paterson, of the British National Illumination Committee had been elected to the Presidency, an announcement which was greeted with acclamation.

M. Filliol, Chairman of the Swiss Committee, was appointed Treasurer of the Commission in Mr. Paterson's place. Dr. J. W. T. Walsh, of the National Physical Laboratory, continues to act as General Secretary.

Details of the actual work of the various Committees cannot be included in this short report of the proceedings at Bellagio.

Brief particulars, however, can be obtained from the "Compte Rendu des Séances," published under the direction of the Central Office of the Commission, and issued from that office at the National Physical Laboratory, Teddington. A report appeared in the "GAS JOURNAL" of Sept. 21, 1927, and can be obtained from the Secretary of our Institution (Mr. Dunn), who attended with me as joint delegate of the Institution at the last plenary meeting of the International Commission on Illumination, which, as already stated, was held in Geneva in 1924.

Mr. ROBERT WATSON (Delegate of the Institution), presenting the Report, said: The meetings of the Executive Committee and the Technical Committees of the International Commission on Illumination, held in Bellagio during the autumn of last year, were intended simply and solely to prepare for the work of the plenary session of the Commission, to be convened later on this year. As a consequence, though considerable progress was made with the work, to ease that which will have to be carried through in September next, the character of the discussions was such that the work was left incompleted, and it awaits full consideration by the Commission. Therefore it would be more fitting to give this Institution a full report of the subjects covered after the plenary session next September. I should like to say, however, that it is a matter of some gratification to the British delegates that Mr. C. C. Paterson, the Director of the Research Laboratories of the General Electric Company, has been elected President of the Commission. Thus for the first time the Presidency will come to this country; and though Dr. Paterson represents electrical interests, I am glad to say, after my long association with him, that he is exceedingly fair-minded in dealing with all the interests concerned on the Commission, and that it has been a great pleasure to work with him.

I should like to make reference also to the fact that the gas members of the Italian Delegation have been very much concerned for some time with the fact that their interest in the work of the Commission has diminished, inasmuch as gas lighting in Italy—as in Switzerland, and in France—is negligible. They have suggested that, in addition to lighting matters, heating subjects should come within the purview of the Commission, and they propose to make that suggestion next September, at the plenary session. The late President, Dr. Hyde, stated that, under its statutes, the Commission is concerned with gas lighting, and not with gas as such; but it is difficult to say at the present time what will be done. Though the interest of some of our brethren on the Continent has diminished in consequence of the relative absence of gas lighting in their respective countries, we in Great Britain are still very much concerned with gas lighting. Mr. Smith, of Tottenham, indicated yesterday that gas lighting is still responsible for a considerable load on many gas undertakings. He said that 75 p.ct. of his consumers are slot-meter consumers, and that each uses about 8000 or 9000 c.ft. per annum for lighting purposes. That is the case throughout the country. Again, we are intensely interested in gas used for street lighting purposes, and, naturally, it is our desire and intention to make every effort to retain that form of lighting which we consider is the best for the purpose. Street lighting is one of the subjects to be discussed fully at the plenary session of the Commission in September.

The PRESIDENT: We in this country must not pass over gas lighting because Italy and France have done so. Gas lighting is very much appreciated, and it is the duty of our Institution to do anything it can to advance it; it is the form of lighting for the medium and the poor man. He can get light, warmth, and ventilation for a penny for five hours by incandescent gas lighting. There is no other form of lighting which is so cheap and so healthy as that provided by modern incandescent gas lighting, and anything that we can do to make it even more economical we must do. Mr. Watson has had this subject always very much at heart, and I must say that the Council of the Institution do appreciate what he has done on the Illumination Commission. In moving the adoption of the report I should like to take the opportunity of saying personally to Mr. Watson that we are intensely interested in this question of illumination.

Mr. C. F. BOTLEY (Hastings): I should like to have the pleasure of seconding the adoption of the report, and of endorsing every word you have said of Mr. Watson, as well as his advocacy of gas for lighting. It is very opportune, and I am very glad he has emphasized the matter. We can see the advantage of having one gentleman associated for a considerable time with this particular matter, because he gets to know the various people concerned with it, and he is able to tell us from his personal knowledge that the President of the Commission, though connected with the electrical industry, is perfectly fair-minded and will deal fairly with the subjects that come before him. Mr. Watson has again agreed to represent the Institution and the National Gas Council in America. We are indebted to him; and I feel sure that our interests in this matter are in safe hands.

The report was adopted.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.

CHAIRMAN'S REPORT FOR THE YEAR 1927, PRESENTED AT THE ANNUAL SPECIAL MEETING ON FRIDAY, FEB. 3, 1928.

The work of the Committee during the past year has been mainly concerned with the widening of its constitution and with the meeting of technical committees of the International Commission on Illumination at Bellagio.

The widening of the constitution of the Committee arose from the feeling that the National Committee, as originally constituted, was not sufficiently representative of the illumination interests which had developed during the past ten years. As regards national standardization work, the National Committee in 1924 asked the British Engineering Standards Association to set up a Sectional Committee on illumination to deal with this subject. The Sectional Committee which has been formed is representative of all bodies interested in illumination matters, and the experience of its working has been particularly happy.

It was felt that as regards the international relations of the Committee a similar widening of its representative character would place it in a much stronger and more authoritative position abroad. In consequence, it was decided to amend the rules of the Committee to make such a change in its constitution possible. Invitations to co-operate in the work of the Committee were accordingly sent and accepted by the following organizations, so that the National Committee now consists of members representing the following:—

Illumination Engineering Society.
Institution of Gas Engineers.
Institution of Electrical Engineers.
National Physical Laboratory.
British Electrical and Allied Manufacturers' Association.
Electrical Lamp Manufacturers' Association.
General Post Office.
His Majesty's Office of Works.
Home Office.
Institution of Municipal and County Engineers.
Association of Public Lighting Engineers.
Medical Research Council.
Ministry of Health.
Ministry of Transport.
National Gas Council.
Railway Companies of Great Britain.
Society of British Gas Industries.
Society of Glass Technology.

The International Commission on Illumination should

have met in plenary session in America in 1927, but in view of the fact that a number of national committees had only recently become members of the Commission it was thought advisable to have a meeting of the technical committees only, and to postpone the plenary meeting until 1928. It is hoped that the advantages of the meeting at Bellagio will be reflected in the proceedings of the plenary meeting in America, which is to take place in September next (1928).

The Bellagio meeting of the International Commission on Illumination from August 31 to September 3, 1927, was attended by seventy representatives from ten different nations. A short account of the meeting was prepared by the British delegates and circulated to members and others interested.

The British delegates were Lt.-Col. K. Edgcumbe, Mr. W. Bush, Mr. L. Gaster, Mr. P. Good, Mr. L. W. B. Jolley, Mr. J. Macintyre, Dr. E. H. Rayner, Mr. R. Watson, Mr. E. Willis, and Mr. H. Buckley, while Mr. C. C. Paterson and Dr. J. W. T. Walsh attended in their respective official capacities of honorary and general secretaries to the Commission.

The main result of a very successful meeting was the reorganization of the technical committees of the Commission, whose numbers were increased to fifteen, and the arrangement by which each country takes charge of one, or in some cases two, subjects in a "Secretariat" capacity. In this way the Central Bureau is relieved of a large amount of administrative work, and it is hoped that the responsibility which is now thrown on the various national committees will stimulate their interest and lead to more efficient operation of the technical committees.

The British delegates provisionally accepted the secretariat responsibility for the two subjects of Daylight Illumination and Coloured Signal Glasses. This acceptance was confirmed at the first meeting of the National Committee after the Bellagio meeting. The sub-committees appointed by the National Committee to deal with these subjects have already had several meetings, and are in touch with the foreign co-operating committees. In addition, the National Committee is co-operating in the work for which the secretariat responsibilities have been allotted to other countries. It is already discussing with Germany Street Lighting and Diffusing Glassware, Automobile Headlights with America, Definitions and Symbols with France, the Photometric Vocabulary with Switzerland; and it appears that there is every prospect of a successful meeting in America this year (1928).

Although it occurred after the close of the year with which this report is concerned, mention must be made of the death of Mr. Gaster, one of our oldest and most esteemed members. Mr. Gaster's association with the illuminating engineering movement and with the National Illumination Committee dates from their beginning, and he has played a large part in their development and progress. His genial and kindly presence will be missed not only in our own deliberations, but at all meetings of illuminating engineers.

(Signed) K. EDGCUMBE, *Chairman.*

Feb. 3, 1928.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.

(*Affiliated to the International Commission on Illumination.*)

REPRESENTATIVES NOMINATED BY THE CONSTITUENT ASSOCIATIONS OF THE COMMITTEE:—

BY THE CONTRIBUTING ASSOCIATIONS:—

Illuminating Engineering Society:

H. BUCKLEY — DR. A. H. LEVY
J. S. DOW — C. C. PATERSON
A. P. TROTTER

The Institution of Gas Engineers:

F. C. BRIGGS — W. J. LIBERTY
W. J. A. BUTTERFIELD — H. E. COPP
R. WATSON

Institution of Electrical Engineers:

LT.-COL. K. EDGCUMBE — J. T. MACGREGOR MORRIS
P. GOODE — H. T. HARRISON
J. M. G. TREZITE

National Physical Laboratory:

SIR J. E. PETAVEL — DR. J. W. T. WALSH.

BY THE CO-OPERATING ASSOCIATIONS:—

British Electrical and Allied Manufacturers' Association:

G. CAMPBELL — T. E. RITCHIE

Electric Lamp Manufacturers' Association:

P. J. BREWER — C. W. SULLY

General Post Office:

MAJOR H. C. GUNTON

His Majesty's Office of Works:

A. G. RAMSEY

Home Office:

D. R. WILSON

Institution of Municipal and County Engineers:

J. SUTCLIFFE

Association of Public Lighting Engineers:

E. J. STEWART

Medical Research Council:

DR. H. HARTRIDGE

Ministry of Health:

R. UNWIN

Ministry of Transport:

E. S PERRIN

National Gas Council:

ROBERT WATSON

Railway Clearing House:

W. C. GOODCHILD — MAJOR G. H. SPITTLE

Society of British Gas Industries:

F. J. GOULD — H. TALBOT

Society of Glass Technology:

B. P. DUDDING

The Committee has made the following appointments:—

Representatives of Great Britain on the Executive Committee of the International Commission on Illumination:—

P. GOODE, R WATSON, and (ex-officio) LT.-COL. K. EDGCUMBE

OFFICERS:

Chairman:

LT.-COL. EDGCUMBE

Vice-Chairmen:

C. C. PATERSON and R. WATSON

Hon. Treasurer:

W. J. A. BUTTERFIELD, 66, Victoria Street, London, S.W.1

Hon. Secretary:

H. BUCKLEY, The National Physical Laboratory, Teddington, Middlesex.

Mr. FRAS. C. BRIGGS (one of the Institution's representatives on the Committee), who presented the report and proposed its adoption, said: I have had the opportunity of representing you on this Committee for only a year; and that year appears to have been one almost entirely of reorganization. The "N.I.C." is a body composed of four co-operating bodies—the Illuminating Engineering Society, The Institution of Gas Engineers, the Institution of Electrical Engineers, and the National Physical Laboratory. It did not appear that these bodies really represented the whole subject of illumination, and, therefore, there have been brought into co-operation with them other bodies representing all possible users of light. Internationally there has been an enormous amount of reorganization, in that, instead of having one Secretariat office in one country, each country represented has been asked to take over the Secretariat duty in connection with particular subjects. This country has taken the fascinating subjects—but not very useful subjects to gas engineers—of signal glasses and daylight illumination, and the Secretariat Committee has been formed in this country to deal with this. Thus, there are Secretariat Committees in various countries, but the "N.I.C." has formed Sub-Committees to deal with the various subjects, including street-lighting, in the Secretariat countries. I do not think I have been connected with a body which has done so much talking with so little practical result; but that may be a distorted impression, because the year has been one of reorganization. Obviously, the "N.I.C." is a body on which the Institution of Gas Engineers needs to be represented very worthily; and I do think that we need a little more of the illuminating expert type of man representing us there than we have at the moment.

Mr. C. S. SHAPLEY (Leeds) seconded the adoption of the report.

The report was adopted.

CARDIFF GAS LIGHT AND COKE COMPANY.

EARLY HISTORY.

The Cardiff Gas Light and Coke Company was incorporated in the year 1837 by Special Act of Parliament—"An Act for Better Lighting with Gas for the Town of Cardiff in the County of Glamorgan." It is well authenticated, however, that gas had been manufactured and supplied earlier than this from works situated on the site of the present fish market in the Hayes. Evidences of these works still exist in the form of several cast-iron retorts, which can be seen built into the wall on the canal side behind the fish market. Cardiff records state that the town was first lighted with gas in 1821, and confirmation exists in the chronicles of Bethany Chapel, in St. Mary Street, that "the meeting house was lighted up with gas on Dec. 2, 1821."

On Nov. 21, 1836, a meeting was held at the Town Hall, Cardiff—the Mayor (Mr. Charles Crofts Williams) in the chair—when it was resolved "That a Company should be formed to be called 'The Cardiff Gas Light and Coke Company,' for effectively lighting the town, the present gas-works being wholly insufficient for the purpose." Mr. Williams was appointed as the first Chairman of the Company.

The first works of the Company were erected on ground purchased from the Marquis of Bute, in Bute Terrace, and were ready for manufacture in March, 1839. Sixty-three public lamps and ninety-three private lights represented the extent of the business, but subsequently the Company progressed so as to require the erection of a new gasholder in 1846. The year 1854 marked considerable progress, and a new Act of Parliament received the Royal Assent. Supplies were extended to the village of Canton under the new powers, and the necessary extension of the plant included a new gasholder, of 200,000 c.ft. capacity, on additional land acquired. Suitable offices were erected in 1856, and provision was included for a showroom with a stock of gas fittings.

Mains were extended in 1860 to supply Roath and East Bute Dock, including the railway and shipping staiths. Consequently a site of land was acquired in 1859 for erection of additional works, which were commenced in 1863 and brought into operation two years later, when the district of Penarth was lighted during the winter months of that year. Meanwhile gas-making continued at Bute Terrace, and was not abandoned until 1907, when manufacture was centralized at Grangetown, and the Bute Terrace buildings were converted for use as fittings stores and distribution workshops.

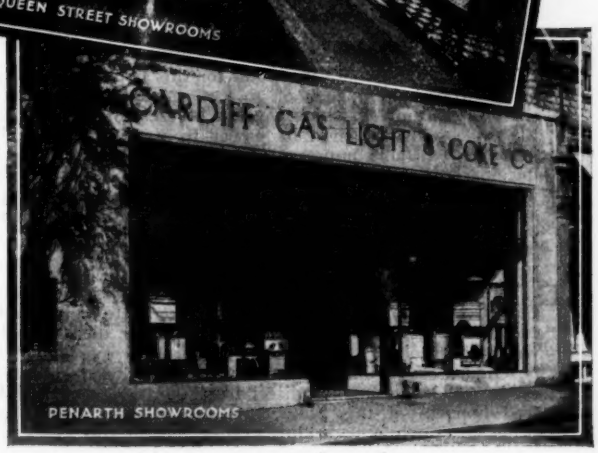
The present chief offices and showrooms in Bute Terrace were erected in 1895. A branch showroom was opened in Penarth in 1903, and new premises were erected in Penarth in 1925. The Whitchurch premises, including showroom, dwelling-houses, and gas transformer station, were built in 1923. The Taffs Well gas undertaking was acquired in 1906; and the Queen Street showrooms were opened in 1910. In 1888 the output of gas was 509 million c.ft.; in 1927 it was 2042 millions.

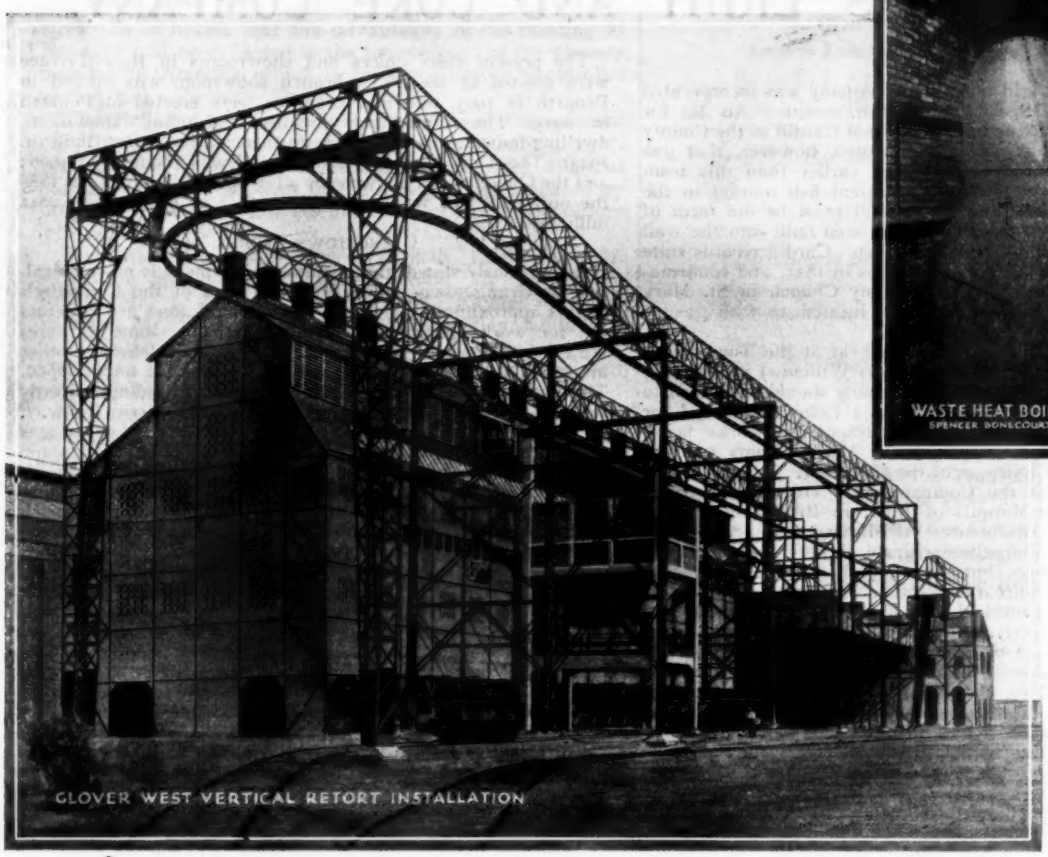
GRANGETOWN WORKS.

As previously stated, the manufacturing plant is now centralized at Grangetown, where the total area of the Company's land is approximately 47 acres, of which 26¾ acres are in actual use for works purposes. Of the remainder, some 4½ acres are utilized as a recreation ground, 2½ acres are leased to other industrial undertakings, and 13¾ acres are as yet undeveloped. The works include high and low level railway sidings directly connected with the Penarth Harbour (Great Western) Railway, vertical and horizontal retort houses, carburetted water gas plant, residual plants for manufacture of sulphate of ammonia and concentrated ammonia, dehydration of tar, coke and breeze washers, laboratories, stores, workshops, locomotive running sheds and garages. The purification plant includes dry purifiers and two sections of washing and scrubbing plant known as No. 1 and No. 2 yards.

All coal is delivered by rail direct from the Company's siding over high-level gantries by five sets of branch rails into the respective coal stores, which are alongside the retort houses. Discharge is effected by fourteen hydraulic rams, and the coal is crushed, elevated, and conveyed to supply hoppers in each case. The coal stores are divided into compartments by brick walls, thus localizing any fires caused by spontaneous combustion of the coal, precautions against which are also taken during unloading.

This plant is known as No. 1 Retort House, and comprises fifteen settings of Glover-West vertical retorts. A first installation of ten settings was erected in 1914 on a site originally occupied by sixty-three settings of direct fired, hand charged, horizontal retorts. The further five vertical settings were added in 1920, and the adjoining site was cleared at the same time for future extensions. The complete installation comprises 120 retorts, each having a daily throughput of 2½ tons of coal, and the gas-making capacity of the plant is rated at 3,750,000 c.ft. The waste heat from ten of the settings is utilized for raising





GLOVER WEST VERTICAL RETORT INSTALLATION

WASTE HEAT BOILER
SPENCER BONECOURT

steam in two waste-heat boilers of the Spencer-Bonecourt type, by means of which approximately 12,000 lbs. of dry steam at 100 lbs. pressure per sq. in. are generated hourly. This is utilized for the steaming process in the vertical retorts and in driving two Sessions steam-engine dynamo units, which, in conjunction with three gas-engine dynamos, generate power of 120 KW. per hour for the electrical operation of the retort house. Steam from waste-heat boilers is used also to augment the general supply for other works purposes. Coke is discharged from the retorts into skips and, after quenching, is elevated and conveyed to the storage hoppers by means of an overhead telpher system.

The carbonizing plant in No. 2 Retort House, which has a capacity of 430 tons per diem, consists of forty settings, each of machine-stoked horizontal retorts 22 in. by 16 in. by 20 ft. long in three tiers, constituting eight retorts to each setting. These are maintained at temperatures of about 1260° C. to carbonize completely charges of approximately 9 cwt. of coal in eight hours. The stoking machinery consists of two electrically driven Fiddes-Aldridge simultaneous discharging-charging machines, installed in 1920, for which power is obtained from No. 2 Power House, which adjoins this retort house at its eastern end. Coke is discharged from the retorts direct into the producer furnaces, or quenched and transported by chain conveyor delivering direct to a 400-ton storage hopper or to yard.

The electrical generating plant for this house consists of two steam-driven units, each of 40 KW. capacity. The motor on the electric runway which conveys breeze from the hoppers to the boilers also receives its power from this plant, while, in addition, two air compressors are installed in the power house for operating capstans on the coal gantries, and for raising water from an artesian well situated near by. This is 435 ft. deep of 13⅜ in. bore, and supplies 11,000 gallons per hour for various purposes on the works.

Carburetted Water Gas Plant.

This section consists of two Humphreys & Glasgow C.W.G. plants, each set forming a complete unit capable of producing 2 million c.ft. of gas per set per diem, fitted with waste-heat boiler. Each boiler evaporates 3500 lbs. of steam per hour, or 55 lbs. per 1000 c.ft. of carburetted water gas made. Coke is supplied direct from the retort houses into the feed hoppers of this plant, and thence over screens to the generators, while travelling cranes handle the ashes. The section is completely equipped with its own exhausting plant, &c. Provision is also made on the site for further extensions, or for the transfer of three reserve plants, each having a capacity of one million c.ft. per diem, which at present are situated near the vertical retort house.

Residual Plants.

A tar dehydration plant erected by the Chemical Engineering Company has a throughput of 4000 gallons of crude tar per 24 hours. Modifications of this plant have been executed to facilitate the manufacture of various grades of prepared tar. A plant by Messrs. W. C. Holmes & Co., Ltd., has a capacity of 5000 gallons per 24 hours.

The sulphate of ammonia plant (Chemical Engineering Company) consists of two sets, each of six tons capacity per diem, and is equipped with neutralizing and drying apparatus. The sulphate produced is perfectly dry, of neutral quality, and contains 21·12 p.ct. nitrogen. The concentrated ammonia plant, erected by the Chemical Engineering Company, has a capacity of 20,000 gallons per 24 hours.

The "Notanos" washery was constructed by Messrs. Head Wrightson & Co., Ltd., and is designed to deal with retort house ashes, separating the combustible matter therefrom, the fuel being utilized for boiler use. The Draper washery is a patent of the Rhondda Engineering Company, Ltd., and is designed for washing breeze and ashes. It is at present employed for grading and screening coke, which is offered for sale as "Broken," "Nuts," and "Beans."

Storage and Distribution.

There are six telescopic gasholders at Grangetown and one at Bute Terrace, having a total capacity of 7¼ million c.ft., to deal with the supply of gas over an area of 66 square miles. From the holders the gas is delivered to the trunk mains supplying the district, through a system of governors which control the supply to the various portions of Cardiff and suburbs. These governors also control the supply of gas to the Bute Terrace and Taffs Well stations, where holders are in operation to supply districts immediately adjacent. Two Rateau fans, each of ½-million c.ft. of gas per hour capacity, and one of 1½ million c.ft. per hour capacity, are in use for raising the pressure during periods of exceptional demands. A Belliss & Morcom compressor is employed for supplying a large outlying area. The compressor is capable of dealing with 300,000 c.ft. of gas per hour at 30 lbs. per sq. in. pressure, and delivers

through a 12 in. steel main to a transformer station at Whitchurch, five miles distant from the works.

LABORATORIES AND WORKSHOPS.

The coal testing plant adjoining the governor house comprises a complete setting of three stop-ended retorts, and operates on 2 cwt. charges of coal. All coals are tested before purchase, and the quality of current deliveries is checked. The tests and temperatures are worked in parallel with the large-scale plant. Four well-equipped laboratories are suitably situated in different parts of the works most convenient for "streams" testing and control of plant.

The works are provided with carpenters', smiths', and engine fitters' shops equipped with modern machine tools. A garage and locomotive running sheds house eight lorries and two locomotives. The yard equipment consists of three locomotives, three travelling cranes, and four "Sentinel" lorries (3 to 4 tons capacity) for coke delivery. There are two stores buildings on the works.

A workmen's dining hall is capable of accommodating all the men of the station. The ground floor is equipped as a central bathroom complete with hot and cold shower baths. A recreation ground provides for football, cricket, baseball, and other sports organized through the Company's Athletic and Social Club. The pavilion and dressing rooms give adequate accommodation.

A first-aid station is situated near one of the entrance gates, and is in telephonic communication with all departments on the works and hospital centres.

From the inception of the Company the administrative offices have been situated in Bute Terrace, on the same site as the works; and until the demand for gas necessitated transferring the manufacture to Grangetown, the whole of the Company's work was carried out here. Consequently, the buildings which were previously occupied for other purposes have been adapted to requirements involved in the progress of the Company's activities. The only portion of the plant retained for its original purpose is a 370,000 c.ft. gasholder, which was erected in 1878 in the position in which it now stands. At Bute Terrace are five Keith Blackman compressors capable of delivering 133,000 c.ft. per hour. These are driven by three 12½-H.P. and two 32-H.P. gas engines. The compressors supply gas from the above holder for the high-pressure requirements of the district, and also deal with the extra demand at peak load. Gas is compressed to 100 in. water gauge and delivered to convenient points in the area, when the pressure is reduced by district governors. The old retort house has been converted into stores, and is fitted for the convenient handling of material and appliances used on the district. A recent extension forms the cooker stores, and is equipped with a loading deck to facilitate handling of heavy goods and appliances.

On the site of the old purifiers a building has been erected for cleaning and repairing gas cookers and other appliances. On the ground floor is a coke-fired furnace for burning off cookers which, after treatment, are passed into this shop for renovation. The shop is equipped with a 9-H.P. gas engine driving a drilling machine, a grinding machine, and two buffing machines; while tinsmiths' and brass finishers' benches are also in the shop. The upper floor is devoted to the repair of meters, where all defective meters from the district are overhauled before being passed for further use. Approximately 10,000 meters are dealt with annually in this shop.

A fleet of seven lorries and motor cars for distribution purposes is garaged in what was originally the coal store. The meter house is now occupied by slot meter inspectors, and the upper floor is used as a staff messroom. The other buildings provide accommodation for men's messrooms, blacksmiths' and carpenters' shops, and a test room, which also serves the purpose of a lecture room.

DINNER TO THE PRESIDENT AND COUNCIL.

The Cardiff Gas Light and Coke Company as Hosts.

The meeting of the Institution was heralded by a complimentary dinner, which was given on Monday evening, June 11, by the Cardiff Gas Light and Coke Company to the President and Council, in the Whitehall Rooms of the Park Hotel. More than 120 guests were invited to enjoy an evening of generous hospitality, during which there were speeches and music. Mr. LAWRENCE G. WILLIAMS (the Chairman of the Company) presided. He had on his right hand Mr. H. D. Madden (the President) and the Deputy Lord Mayor of Cardiff (Councillor W. G. Howell); and on his left Sir David Milne-Watson, LL.D., D.L. Others to whom seats were allotted at the top table were: Mr. Robert H. Williams, J.P. (Deputy-Chairman of the Company), Mr. James Miles, J.P. (Director), Mr. William Ware, J.P. (Director), Mr. W. Doig Gibb, O.B.E., Sir Arthur Duckham, K.C.B., Mr. John Terrace, Mr. F. W. Goodenough, C.B.E., Mr. C. S. Shapley, Alderman C. H. Bird, J.P., Mr. Finlay A. Gibson, Sir Paul Makins, Bart., Mr. T. H. F. Lapthorn, J.P., Mr. W. E. Price, Mr. John Wilkinson, O.B.E., Mr. W. J. A. Butterfield, Mr. C. F. Botley, Mr. J. Ferguson Bell, J.P., Mr. R. H. March, F.C.A., Mr. H. C. Honey, Mr. T. A. Davies, and Mr. S. S. Ogilvie. The vice-chairs were occupied by Mr. R. J. Auckland (Secretary of the Company), Mr. F. Boardman (Assistant Engineer), Mr. B. J. Bell (District Superintendent), and Mr. Octavius Thomas (Hon. Secretary of the Reception Committee).

The CHAIRMAN, after the toast of "The King" had been honoured, said: The Prince of Wales, who is an Honorary Life Member of The Institution of Gas Engineers, will be here among us to-morrow, and I am sure will receive a welcome which will be a credit to our country. No man works harder, no man is a better sportsman, or more worthy of having his health drunk in the manner in which I am sure you will drink it. I give you "The Prince of Wales and the Rest of the Royal Family."

The toast having been enthusiastically received,

Sir ARTHUR DUCKHAM said: I am delighted to be here with you to-night; and it falls to my lot to propose the toast of "The City of Cardiff." We appreciate our welcome here; and I am certain you will feel by the end of the week that you have had a most heartfelt welcome to this great city. Those of you who have not been here before must feel that here there is something unexpected, in a city which is associated with coal, steel works, and docks. You have come to a beautiful city, with possibly the finest public buildings that are to be found. It is a city magnificently laid out, and possessing a very real and very true civic sense. I believe this is the first time the Institution have held a meeting in Wales. Of course, this question of nationality is not of very great importance to us, but it is still of some importance. The main thing that appeals to us as gas people in coming to Cardiff is that we find there one of the greatest engineers in this country. The second thing that appeals to us is the close association of that city with the centre of the South Wales coal industry. Now, we all appreciate very fully that coal is the life blood of the British nation; and we do our best, each in his own sphere, to make use of coal. There has been a terrible depression for some time in the coal industry; but coming here, I am sure we should all like to bring a measure of hope to the coal industry of Cardiff. All of us here are believers in coal. It provides most of us with our living. We are most intensely interested in coal; and I think I am voicing the general feeling when I say that we wish to see a betterment of the coal position in this country. I feel that the coal situation must improve. The fact is that there is a demand which is less than the supply; and the industry is also suffering because there has been such keen competition from abroad, and from within.

KEEN COAL COMPETITION.

Dealing with the competition from abroad, I may say I have returned recently from Germany. One feels that the menace of German competition is going to be less in the future than it has been in the past. Colossal sums of money have been spent in Germany on the industry. Of course, you will realize that the money spent in Germany recently has been to a certain extent wiped out by the stabilization of the mark. Germany has, however, borrowed lavishly from America, and in the Essen district and in the Ruhr generally, within quite recent times, sums up to £30,000,000 sterling have been borrowed for works. Now that money has got to be paid for. Americans are not going to let them have it for nothing; and the payment of the interest is going to make their coal output cost them more. The standard of living in Germany is higher to-day than I have ever seen it. The workers expect higher pay, and the cost of production is going up. I think, therefore, that German competition in the coal trade, and I hope also in the iron and steel trades, will gradually lessen until it becomes what may be considered perfectly fair and normal competition. That is going to help this great city of Cardiff. Very much the same may be said of France. The only countries in Europe with regard to which anxiety may be felt are Belgium and Luxemburg, where wages and the standard of life are considerably lower than in this country. No doubt, however, the workpeople in those countries will awake to the position, and demand a higher standard of living, in which case competition will become less intense. Therefore I do feel that things must get better in the coal trade and the heavy industries.

I do also feel that there has been a great deal of competition from within. My friends of the gas industry do not alto-

gether dislike competition from within. They have no objection to a man coming along and offering them a large amount of coal at (say) 35s. a ton, then somebody else offering the same quantity at 34s., the original man coming down to 33s., the second one to 32s. 6d., and the bargain being finally struck at 32s. But I feel that such a state of things is not altogether good for the coal industry, especially at the present time. Certain steps, in fact, have been taken by the coal industry to prevent such competition; and I do not think our friends in the gas industry will complain much about these steps being taken, until things get better for the coal industry.

We are intensely interested in our visit to Cardiff; and we much appreciate the welcome we are receiving. I have to couple with this toast the name of Councillor W. G. Howell, Deputy Lord Mayor of Cardiff. There is one thing that we in this land can pride ourselves upon, and that is our wonderful municipal government. The time and the energies expended by men who take up municipal service are beyond all praise. In Cardiff the whole of the municipal services are absolutely beyond reproach.

The Deputy Lord Mayor.

Councillor W. G. HOWELL (Deputy Lord Mayor of Cardiff): In the first place, I have to offer you the very sincere apologies of the Lord Mayor for his inability to accept, in consequence of the Royal visit to-morrow, your hospitality to-night. He has asked me to represent him at this function; I have been very pleased to do so, and to accept your generous hospitality. To-morrow the Lord Mayor is to welcome you; but in the meantime he has asked me to extend to you a very cordial greeting. I feel a very great responsibility in replying to this important toast; and I want to thank Sir Arthur Duckham for the very kind way in which he has proposed it. There was cordiality and warmth about his utterances which I, on behalf of the citizens of Cardiff, much appreciate. We all are very proud of our city, and I am sure no one will take exception to that. Reference has been made to some of the public buildings; and I trust you will take an opportunity of inspecting them. Among our important institutions is the Cardiff Gas Light and Coke Company. One is always delighted to have dealings with them—they are so courteous, so prompt, and so efficient in every possible way. I feel I should be wanting in what is due from me to that Company if I did not bear testimony to the fact. [Applause.] Those on the Council are doing their best to uplift the community, and to make Cardiff a better place to live in. Trade at present is rather depressed; but we are not losing heart. We are hoping that things may improve as a result of your visit. You can do us some good. I believe that, with hard work, patience, faith, hope, and courage, the day is not far distant when we shall again achieve a measure of prosperity.

An Ideal President.

Sir DAVID MILNE-WATSON: I suppose I may fairly claim the toast which I now have the pleasure to propose—that of "The Institution of Gas Engineers"—to be the toast of the evening; and I will ask you to drink it with enthusiasm. When I arrived here, I hoped I should not be required to speak in Welsh; and in the course of a short stroll in this beautiful city I have been relieved to find that the inhabitants do not speak Welsh—and they do not understand Scotch. [Laughter.] But by the use of my best English, I managed to make myself understood, and to see some of your wonderful buildings. It is of special interest to me to be here to propose this toast, because my old friend Mr. Madden is your President. Mr. Madden, as most of you know, was educated and brought up in the Gas Light and Coke Company. Therefore I have almost a fatherly feeling towards him; and when he asked me to come to Cardiff and propose this toast, I did so with the very greatest pleasure. In Mr. Madden you have an ideal President for the Institution; and I am sure you are very lucky indeed that he has asked you to spend these three or four days with him in this city of beauty, as we are told in the papers, and as we have seen for ourselves, it is. I have no doubt you will find that Mr. Madden's gas-works are in the same condition as is the city itself. I am only sorry that business calls me away to-morrow morning by an early train, so that I shall not be able to stay to move a vote of thanks to Mr. Madden for his address. I can assure you that it is only imperative business in connection with the gas industry as a whole which will call me away. But for that, I should have been extremely pleased to stay with you. The Institution of Gas Engineers is, I am sure you will all agree with me, a most important body. ["Hear, hear."] It is the scientific body of the gas industry. Founded in 1863, it is of a very respectable age, and it has carried on its scientific traditions most worthily. I am glad to say it is not standing still, but is going forward from victory to victory. I am hoping its career may be very soon crowned by the grant of a Royal Charter. I only wish it might have been possible for that Charter to be conferred on this occasion. But, at any rate, I am perfectly certain that if any Institution ever deserved a Royal Charter, it is the Institution of Gas Engineers, which represents the scientific side of our industry, just as the National Gas Council represents the political and legal side, and the British Commercial Gas Association represents the advertising side—all very necessary functions of the gas industry. Then we have the Federation of Gas Employers, which is also very important; and I am exceedingly pleased to see here to-night my friend Mr. Will Thorne, who is Vice-President of the Joint Industrial Council for the Gas Industry. [Applause.] We are, in fact, meeting together as a happy family representing the various organizations of the gas industry. That makes this meeting such an important one.

The Institution Going Ahead.

I am very glad to think that you in the Institution are going ahead all the time with scientific work, because on that side you are the brains of the industry. Looking down the papers which are to be read, I see you are dealing with all manner of subjects which are cognate to the welfare of the industry. An industry like ours cannot afford to stand still; we must always be forging ahead. That specially applies to an old industry like ours, because the public generally are rather apt to take an interest in new-fangled things. They are very anxious to make out that we are old-fashioned, and that gas is done with. It is not done with; I believe it is only at the beginning of its career. But we have got to make the public realize this. We have to build on sound foundations, and you on the scientific side are capable of laying those foundations. I am certain you will lay them fairly and well. It is no use hoping to go on and prosper if we are content to remain on the old lines. We have to be alive to every new development and to every scientific discovery, and to take advantage of all the new movements going on in the world. I believe that, notwithstanding the fact that electricity claims to be the thing of the future, we in the gas industry have a great heritage and a very great future. Look where you will, you find that the modern problems—such as that of the hydrogenation of coal—are intimately gas questions; and I am perfectly certain it lies with us to a great extent to decide what we make of this industry. We have had a glorious and splendid past; and I believe that we shall have a glorious and splendid future. If you, gentlemen, will back us, who are looking after the legal and political sides, I believe that the future of the gas industry will be as good as, if not better than, its past. ["Hear, hear."] I do not think it is necessary for me to say anything more in commending this toast. You have an ideal President and a splendid place of meeting; and I am perfectly certain that your conference of 1928 will mark a stage in the progress of a great industry.

The President.

Mr. H. D. MADDEN: It is rather difficult for a President who only acts for one year in his life to respond to the toast of "The Institution of Gas Engineers." It would take a long time for me to explain to outsiders, but not to you who are within the industry, what the Institution stands for. Sir David Milne-Watson has told you what it does really do. He has spoken of the scientific side and its political, legal, and advertising sides. They are all represented here this evening; and we have also with us an old colleague of mine on the labour side, Mr. Will Thorne. I may say that, like myself, he is a Beckton man. Sir David has paid me a tribute. I take it as a great tribute that, as Governor of the chief Gas Company in the world, he should have come down to be present on this occasion. The Gas Light and Coke Company carbonize over 2,000,000 tons of coal a year; and I would like to stress the point that they supply more energy, on an equable basis, than the whole of the electrical industry in Great Britain combined. This is a point that should not be lost sight of. I have also to thank him for another thing. Soon after I became President, he—through his Chief Engineer, my old friend, Mr. Thomas Hardie—offered me two wonderful papers—those by Mr. Lacey, their Distributing Engineer, and by Mr. Hollings, their Chief Gas Chemist. I did not have to seek the papers. Through Sir David they were offered, to make this meeting a great success. They are papers on most important subjects to the industry to-day—the two greatest problems we as engineers have to face. In the first place, we have to give the consumers a supply of gas. That is one of the problems we are always investigating; and Mr. Lacey gives his time to it. On the other side we have Mr. Hollings, who is devoting his attention to the chemical aspect. I should like to thank Sir David.

Public Service.

If the industry stands for one thing, it is for public service. It has to its credit 120 years of public service. It gives to the ordinary man in the street fuel for light, heat, or whatever he wants. Through mains which are under the ground, and are unseen, it furnishes him with a supply of fuel which his wife appreciates. The industry helps the municipality, because there is less carriage of coal, and ash carts are becoming fewer. In Cardiff, there are 59,000 gas cookers at work on Sunday, when we experience our peak load; and when you think of the clear air we enjoy in Cardiff, you must remember that 59,000 dinners are cooked every Sunday by means of gas. Surely, therefore, this Institution stands for pure air in our cities; it stands for smoke abatement, with its attendant evils. We represent service to the consumers whom we have the honour to supply; and we have to give them of our very best,

We can only do this by means of research, in which respect we are but at the beginning of things. With regard to carbonization, we are now working in several directions, one of which is the blending of coals. I think the time is coming when we shall find a method of blending that will give us a solid fuel which will displace the 36,000,000 tons of coal which are used by the private consumer, and one-half of which goes up in smoke to pollute the atmosphere. If the research work of the Institution does secure that, we shall have accomplished much. Another thing the Institution are doing which will affect the welfare of the people is to investigate the radiant heat of gas fires, which are being sold at a tremendous rate—so tremendous indeed that the makers have a difficulty in giving prompt delivery. What I am referring to is the work of Sir Henry Gauvain at Alton on the therapeutic value of gas heating and lighting for invalids and children. The Institution are fathering that. These, however, are not the only researches that the Institution have in hand.

National Service.

Again, the Institution stands for education in our industry. What has been done in the last few years shows that we have an educational system which will fit men to take their places in serving the public. That is its first object; for if any public utility undertaking in this country ever stood for service, it is the gas industry. Where would this country have been during the great war, if it had not been for the gas industry? After Germany declared war, there was found to be a shortage of munitions. Lord Moulton, the Director of High Explosives, called the gas engineers together, and said he wanted high explosives for munitions and antiseptics for the wounded. They were called upon as a body to supply them, and it was done. The industry is thus not only a public service, but it is a national service. I feel that if the Welsh coalfields are to be brought back to prosperity, the carbonizing industries can assist; and in this connection, I would like to say: "Welsh tar for Welsh roads, made from Welsh coals." The Institution have this year applied for a Royal Charter; and I think we are entitled to it. In view of our war work, our national work, and our public service, if any Institution ought to have a Royal Charter, it is The Institution of Gas Engineers.

The Hosts.

Mr. F. W. GOODENOUGH: I am sure every member of the Institution present this evening would be very glad to have the privilege of proposing the toast which I have the honour to submit to you—that of our hosts, the Directors and Officers of the Cardiff Gas Light and Coke Company. We are greatly indebted to them for their hospitality; and we are all of us very glad to find ourselves in Cardiff for the meeting of the Institution. As Chairman of the Executive of the British Commercial Gas Association, I do feel that I have a right to propose this toast, because that Association owes a very great deal to the support of the Cardiff Gas Company in Wales. The Cardiff Gas Company always leads in Wales, and it has from the very beginning given Wales a lead in support of all the national organizations of the industry—not only the Association that I have the honour to represent, but the National Gas Council and other bodies. We have had as our Vice-President Col. Oakden Fisher, a former Chairman of the Company. He was one of the first Vice-Presidents of the "B.C.G.A." Then there was our dear old friend Mr. Dovey; and now we have our Chairman of to-night, Mr. Lawrence Williams, whom all of you who know him recognize as a worthy successor to his distinguished predecessors. We wish to drink the health of the Directors, and also of the officers.

A Beloved Chief.

I am sure the Directors will forgive me if I refer more particularly to our good friend Mr. Madden. It is natural that every one speaking to-night should refer to Mr. Madden, your President. I refer to him with the very greatest pleasure as an old colleague, and I am glad to say an old friend, and also as one who has worked hard with the other members of the Education Committee of the Institution in bringing the scheme to the degree of success which it has so far attained. Mr. Madden is the Chairman of the Board of Examiners, and that has meant a great deal of work for him. He has always been a most enthusiastic member of the Committee; and I am glad to pay my tribute to his work in this connection. He is a zealot for education; and the industry owes a great deal to him for his work in this connection. The Cardiff gas undertaking also owes to Mr. Madden, not only many visible assets in the splendid position of its works, but many invisible assets which are of the greatest value to the Company—the goodwill of its customers, the goodwill of its staff, of whom Mr. Madden is the beloved Chief, and the goodwill of the Press, which is always wisely and well looked after. Mr. Madden is building up for his Company a great invisible asset in this goodwill of its customers, and of the Municipality of the city which it serves. May I say how glad one is to see here our old friend, Mr. George Clarry, who was one of the original members of the Executive of the "B.C.G.A.," and whom we were very sorry to lose? We are delighted to find him in the best of health. Then we have Mr. Auckland, who is a first-class Secretary, and Mr. Bell, in whom the Company have a very efficient District Superintendent. We know Mr. Bell well in connection with the Salesmen's Circles, and also in connection with education work; and I cannot speak too highly of the assistance we have had from him. With the great leader you possess in Mr. Madden, and the able assistants he has, this Company are assured of even greater prosperity in the future than they have had in the past, though 300 p.ct. increase in forty years (of which the Company may well be proud) is one which they may have some task in living up to in years to come. I wish them all success, and thank them for their hospitality this evening and for all they are doing for us this week.

The Company's Record.

The CHAIRMAN: I thank you very sincerely, on behalf of my fellow Directors and myself, for the generous and courteous manner in which you have received the toast of "The Cardiff Gas Light and Coke Company." I should like especially to thank the Deputy Lord Mayor for the very kind way in which he referred to the courtesy of the staff of the Company—which remark, I presume, he extends to the Directors. Without anticipating the words of welcome which my Directors desire me to extend to the Institution of Gas Engineers at to-morrow morning's opening session, I cannot refrain from expressing the pleasure it affords me, equally with the rest of our Board, that your Institution is visiting Cardiff this year for the annual meeting.

It was with great pleasure that we learned twelve months ago that our Engineer and Manager, Mr. Madden, had been selected to be your President for the year now being closed by this meeting. The Directors of this Company have no need of confirmation of their wisdom in selecting Mr. Madden some 22 years ago to join our staff, because his subsequent record has fully justified the confidence then placed in him. Since then we have appointed him first as Engineer in 1909, and subsequently to be our Engineer and Manager. Nevertheless, we are highly gratified that his colleagues in the gas industry should have paid him this honour in the year that has passed. The record of this Company during the period since Mr. Madden joined us has been one of continuous progress and success. In 1906, the number of consumers was 27,783, and the output of gas from the works totalled 1012 million c.ft. In 1927, the corresponding figures were 54,474 consumers and 2042 million c.ft. gas output. We have therefore more than doubled the size of our undertaking.

I need hardly remind you, who are gas engineers in charge of important manufacturing stations, of the constant care and attention to duty that is involved in furnishing a city of the size and importance of Cardiff with a continuous and uninterrupted supply of gas in such increasing quantities over a long period of years; and this Mr. Madden has achieved with conspicuous success. The character, as well as the size, of our works has undergone a very complete change. When your President arrived among us, we were scarcely as up to date as we are to-day. In those times, the whole of the gas supplied was manufactured in direct-fired hand-stoked horizontal retorts. We had neither vertical retorts nor oil gas plants to aid the supply to the town; nor did we deal effectively with any of our important residual products, save coke. To-day, as you will learn when you inspect our works, our methods are much more advanced; and I trust your visit to Grangetown will be a source of interest and pleasure.

I do not propose to detain you at this hour with a long speech; but I do desire most sincerely to express the pleasure it has afforded the Directors of the Company to entertain to-night the President and Council of the Institution, together with the other distinguished gentlemen connected with the gas industry who have honoured us by visiting Cardiff. We have appreciated very highly the pleasure of your company.

The proceedings were brought to a close with the singing of the Welsh National Anthem.

FORTHCOMING ENGAGEMENTS.

June 29.—WAVERLEY ASSOCIATION OF GAS MANAGERS.—Annual meeting in the Chambers Institute, High Street, Peebles. Presidential Address of Mr. George Urquhart (Tranent). 11 a.m.

July 4-5.—ASSOCIATION OF STATUTORY INSPECTORS OF GAS METERS.—Annual conference in Birmingham.

July 9-12.—ASSOCIATION OF PUBLIC LIGHTING ENGINEERS.—Annual meeting and conference in Sheffield.

Oct. 22-24.—BRITISH COMMERCIAL GAS ASSOCIATION.—Annual Conference at York.

The Institution of Gas Engineers.

All meetings take place in the Council Room at 28, Grosvenor Gardens, unless otherwise stated.

June 25.—Special Emergency Committee.

July 10.—Gas Education Committee.

July 16.—Emergency and Finance Committees and Benevolent Fund Committee of Management in the morning; Royal Charter Committee meeting and Council meeting in the afternoon.

MISCELLANEOUS NEWS.

SHEFFIELD GAS PRICES REDUCED.

Gas at 1s. per 1000 C.Ft.

A further reduction in the price of gas has been announced by the Directors of the Sheffield Gas Company, to take effect from the readings of the meters for the June quarter. The prices will then be as follows:

For gas supplied in quantities up to 500 therms (100,000 c.ft.), 6⅜d. per therm, equal to 2s. 9d. per 1000 c.ft.;

For the excess beyond the 500 therms up to 2500 therms (500,000 c.ft.), 5d. per therm, equal to 2s. 1d. per 1000 c.ft.;

For the excess beyond 2500 therms up to 15,000 therms (3,000,000 c.ft.), 4⅛d. per therm, equal to 2s. per 1000 c.ft.;

For the excess beyond 15,000 therms up to 30,000 therms (6,000,000 c.ft.), 4⅝d. per therm, equal to 1s. 11d. per 1000 c.ft.;

For the excess beyond 30,000 therms up to 50,000 therms (10,000,000 c.ft.), 2⅝d. per therm, equal to 1s. 2d. per 1000 c.ft.

For the excess beyond 50,000 therms up to 125,000 therms (25,000,000 c.ft.), 2 7/10d. per therm, equal to 1s. 1⅛d. per 1000 c.ft.;

For the excess beyond 125,000 therms up to 250,000 therms (50,000,000 c.ft.), 2⅜d. per therm, equal to 1s. 1d. per 1000 c.ft.

For the excess beyond 250,000 therms up to 375,000 therms (75,000,000 c.ft.), 2⅛d. per therm, equal to 1s. 0⅛d. per 1000 c.ft.;

For the excess beyond 375,000 therms (75,000,000 c.ft.), 2⅛d. per therm, equal to 1s. per 1000 c.ft.

for all gas consumed in any one year on one and the same premises.

REDHILL GAS COMPANY.

Amalgamation with the Dorking Undertaking—Proposed Change of Name.

An Extraordinary General Meeting of the Redhill Gas Company was held at the Club Room at the Redhill Gas-Works on June 11, for the purpose of considering an application by the Company to the Board of Trade for a Special Order under section 10 of the Gas Regulation Act, to (among other matters) change the name of the Company, to authorize the amalgamation with and vesting in the Company of the undertaking of the Dorking Gas Company, and for the purposes of the undertaking of the Company to raise additional capital stock and loan capital of the respective amounts stated in the proposed draft Special Order, and to confer further powers upon the Company. The occasion was one of considerable interest, the proposal following upon the absorption in recent years by the Redhill Company of the Reigate and the Godstone undertakings. It is proposed that the Company shall be known in future as "The East Surrey Gas Company," in view of the large area its operations will cover in the event of the Special Order being confirmed by the Board of Trade.

Mr. W. LEES STENNING, J.P. (Chairman), who presided, said that, in these days, when competition was so keen, charges could only be reduced and the security of capital maintained by working on the largest scale possible. They had had this view continuously before them since the war, and during the last seven years had taken the opportunity to absorb the Reigate and the Godstone undertakings, with great benefit to the gas-consuming public and, though necessarily to a lesser extent, the stockholders of the Company. The Dorking Company found it had arrived at a time when, if continued as a separate entity, much expenditure would be necessary at the works to cope with the increasing demand in the winter months. They (the Redhill Company), on their part, had adequate works plant for their present requirements, and to spare. They also had trunk mains within two miles of the Dorking Works; and it would be a simple and comparatively inexpensive matter to connect up and deliver to the Dorking area such extra supplies as might be required there. There would be a considerable saving in overhead charges.

THE PROPOSED TERMS.

The Dorking Company was a maximum dividend Company, which had paid the permitted maximum of 10 p.ct., 7 p.ct., and 5 p.ct. upon the respective classes of their capital for many years, and, in addition, had built up a considerable reserve fund. The terms provided that each "A" and "B" share in the Dorking Company should be exchanged for £50 of their 5½ p.ct. preference stock; for each "C" share there should be given £35 of their 5½ p.ct. preference stock; and for each "D" share £25 of that stock. Holders of 5 p.ct. debenture stock in the Dorking Company would be given in exchange an equal amount of their 5 p.ct. debenture stock. The Dorking Company's reserve fund would form part of the reserves of the combined undertaking which would, on the date of transfer, take over all the Dorking assets and discharge their liabilities. Provision was made for compensating the retiring Directors, Secretary, Auditors, and Managing Directors for the loss of their present offices, and for the appointment of Mr. John Urquhart, who had so successfully managed the Dorking Company for fifteen years, to a seat on their Board. With regard to the Dorking workmen, they undertook that unemployment should not result from the amalgamation. Mr. Lees Stenning then mentioned the proposed change of name of the Company.

Mr. W. H. BENNETT (Managing Director) explained in detail the provisions of the draft Special Order.

The resolution was then put to the meeting, and passed unanimously.

On the same day an extraordinary meeting of the Dorking Gas Company took place; and the resolution regarding the amalgamation was carried, with only one dissentient.

THE MALTA AND MEDITERRANEAN GAS COMPANY LTD.

The Ordinary General Meeting of the shareholders of the above Company was held at the offices, 59 and 60, Gracechurch Street, E.C. 3, on Tuesday, June 12. Mr. A. M. PADDON, M.Inst.C.E., Chairman of the Directors, presided.

The CHAIRMAN, in presenting the Directors' report, which showed an amount of £22,226 standing to the credit of profit and loss, said that any discrepancy between the merits of the present report and the one which the Directors submitted a year ago arose out of only one fact, which was at once definite and entirely outside the Company's control—namely, the withdrawal of naval and military forces from Malta to meet the disturbances in the Far East. The withdrawal had actually taken place on the occasion of the Meeting last year, but at that time it was hoped that it would be temporary in its incidence, and not very pronounced in its consequences. But, contrary to their optimistic expectations, it had continued, though its intensity as an adverse factor to the Company's business had now been considerably diminished, and at the present time the Company might be said to be reverting to business in normal volume. The withdrawal of a single battleship from Malta meant the taking away of practically a thousand persons, and, if the ancillary services be counted, very many more. Thus it was easy to see what disarrangement of business such movements caused. In the natural order of affairs, of course, replacement must come about, and to some extent it had already come about, though not completely. But for this circumstance, the accounts were well up to what he thought he might call the excellence of the previous occasion. The cause just mentioned had brought about a diminution of nearly 6 p.ct. in the business, and this had its effect on the credit side of the revenue account by reducing receipts from the sale of gas by £2350, and, as an inevitable corollary, by reducing the receipts from residuals by £286. On the other side, the Company had had to pay £1200 less for coal, and that, in some degree, corrected the adverse balance. Coke, again, was governed by these general conditions, the price here influencing prices in the South of Europe; and the Company had received only some 42s. a ton for coke, whereas 10s. more was received in the previous year.

The net result was that the profit for the year—£13,461—was nearly £3000 less than previously. Nevertheless, it furnished very ample means for meeting all the demands made upon the Company in the way of dividend—a dividend which it was proposed to maintain at the increased rate which was adopted a year ago. Having paid this, and having improved the position in certain other respects, they still had a very ample margin. The sum carried forward on the profit and loss account was £22,226, which would be diminished only by some £4700 on account of the dividend, leaving a large floating balance to carry forward for future requirements. Of course, a floating balance might have many different intrinsic values, but here it had its full credit significance when taken in connection with certain items set out in the balance-sheet. The investments of the Company in gilt-edged securities had been increased by £7200 during the past twelve months, bringing the total investments in stocks to over £80,000, whereas the ordinary capital of the Company amounted only to £75,000. But there was still another entry that was encouraging. This £80,000 in Government and Bank of England stocks amounted to close on £86,000 in realizable value at the present moment. Therefore anything that the Company showed in the way of undivided profits or carry forward rested on a very substantial condition of affairs at the bank. The amortizement account had been increased by over £2000, and the reserve account, which stood at £26,720, by practically its interest. The rest of the investments stood in general account, but wherever they stood, there they were as definite securities held by the Company, and available for the purposes of the Company at any time and in any way required.

What the shareholders would be concerned with most, however, were the prospects before the Company. These were distinctly more encouraging than six months ago. At that time the decreases in output caused the Directors some concern—not profound concern, because they knew to what they were due, and that the phase must pass. Towards the close of the year, however, these monthly decreases tended to disappear, and now the normal relations had practically been resumed. The first month of the Company's year—April—still showed a small decrease, but nothing like those which had taken place earlier. They had been informed that the Government programme contemplated a considerable establishment at Malta; if this expectation had not been fulfilled, it was still entertained by the Government. Malta had not lost in importance by recent events. It remained the key of the situation. Therefore the prospects were at least as good as they were twelve months ago, and he thought, all things considered, a little better. The relations with the authorities out there were excellent, and he thought the future could be regarded with considerable confidence. The Company had already bought coal for more than half of the next twelve months at the lowest rate since the war, and a new vitality seemed to be creeping into the undertaking, despite a temporary setback. In the essential details of finance they were stronger than twelve months ago.

He then moved the adoption of the report and accounts.

Mr. STRACHAN CHILD CLARKE seconded.

Mr. DORMOR (a shareholder) asked for an explanation of the item "general trade charges" (£1872), as distinct from "maintenance, renewals, and improvements."

The CHAIRMAN said that that question had puzzled him some forty years ago, when he first came into touch with gas undertakings. It was a technical heading comprising a number of matters which were more or less kept on a common basis in practice. It was distinct from maintenance, renewals, and improvements. These latter had to be carefully crystallized and defined, otherwise the undertaking could not be run, but "trade charges" comprised almost

everything else. For example, it might include insurance, local rates and taxes, rent at Malta, or banker's charges. Shareholders would realize that all these things had been looked into by the auditors before they were set out in the printed accounts at all.

A SHAREHOLDER said that, on comparing the present figures with the balance-sheet of seven years ago, he found that in 1921 the fixed assets (investment on works and plant) were valued at £113,884, and in seven years had been reduced to £95,219. While that had been going on, the investments in Government stock had increased from £10,344 to £80,338—a gain of £70,000 in seven years. It seemed to him that the shareholders might rest without anxiety.

The motion to adopt the report and accounts was carried unanimously, as was a further resolution from the Chair, "That a dividend of 4 p.ct. on the Ordinary Shares, free of tax, making, with the interim dividend paid in December last, 8 p.ct. for the year, be paid; also a dividend of 3½ p.ct. on the First Preference Shares, and 3¾ p.ct. on the Second Preference Shares, less tax at 4s. in the £."

On the motion of the CHAIRMAN, seconded by Mr. F. H. JONES, the Director retiring by rotation (Mr. Strachan Child Clarke) was unanimously re-elected. The Chairman said that Mr. Clarke's business was largely in the South of Europe, which made him particularly conversant with the work of the Company, and a great asset to the Board.

It was agreed to re-elect the auditors, Mr. William Cash, F.C.A., and Mr. Hyde Clarke Burton, A.C.A.; their remuneration being fixed at forty guineas each.

The CHAIRMAN then moved a hearty vote of thanks to the Officers, who had for so many years given good and satisfactory service. He included the Staff in London as well as in Malta. This was carried with acclamation, and Mr. C. J. DAUN, the Secretary, expressed his acknowledgments on behalf of the Staff.

The only other business was a cordial vote of thanks to the Chairman and the Directors, which was proposed and seconded from the body of the Meeting, and heartily carried.

TRADE NOTES.

Holmes' Brush Washers.

In their latest folder, Messrs. W. C. Holmes & Co., Ltd., of Huddersfield, concentrate on their brush washers for the extraction of ammonia, benzole, naphthalene, water vapour, &c.

Lifting and Shifting.

The folders published by Messrs. Herbert Morris, Ltd., of Loughborough, are always original; and in their latest issue the humorous approach to the subject of lifting machinery is certainly effective.

The Hydronyl Syndicate, Ltd.

This firm have received an order from the Brentwood Gas Company for packing a new scrubber with their Lessing patent contact rings. This is the second scrubber of this system to be installed by this Company; the first one having been erected in 1924.

New Purifiers for Swindon.

The Swindon Gas Company have recently placed an order with Messrs. W. J. Jenkins & Co., Ltd., Retford, Notts, for a complete purifying installation, consisting of five boxes complete with valves and connections, purifier house, and oxide handling plant.

Sharples Centrifugal Purifiers.

A beautifully illustrated booklet of forty pages, dealing with the Sharples super-centrifuge and its many applications, has been published by Super-Centrifugal Engineers, Ltd., Aldwych House, W.C. 2. The firm will be glad to supply any of our readers with a copy on request.

The Mechanism of a Dry Gas Meter.

A booklet of unusual interest has been published by Messrs. Thomas Glover & Co., Ltd., which describes in detail, and illustrates by a series of diagrams, the mechanism and action of a dry gas meter. The firm will be pleased to forward a copy to any gas engineer on request.

"W-D" Intermittents for Southall.

The Gas Light and Coke Company have placed a contract with the Woodall-Duckham Vertical Retort and Oven Construction Company (1920), Ltd., for an installation of "W-D" intermittent vertical chambers at their Southall station, capable of producing about 4,750,000 c.ft. of gas per day from average Durham run-of-mine coal. The new plant will consist of two benches, each containing twenty-four chambers, and will be complete with coal and coke handling plant and duplicate waste-heat boilers.

Lighting Trades, Ltd.

The annual outing of the employees of the "Ironclad" Gas Mantle Factory at Earlsfield, S.W. 18, of Lighting Trades, Ltd., took place on Monday, June 11; a very pleasant day being spent at Bognor. The majority of the party, numbering nearly 300, had elected to travel by road; and after an enjoyable run reached their destination soon after midday. A heavy shower of rain greeted the party on arrival, but brilliant sunshine followed, and remained for the rest of the day. Following tea, which was presided over by Mr. W. Heap, the Works Manager, the party enjoyed their own desires until 6.30 p.m., when the return journey was commenced.

Falk, Stadelmann, & Co., Ltd.—An offer for sale is being made of 450,000 7 p.ct. cumulative preference shares of £1 each at par, and 112,500 ordinary shares at 22s. per share, in this Company. An arrangement has been made whereby customers and employees of the Company will obtain preferential consideration in respect of applications made for the shares.

COAL TRADE REPORTS.

From Our Own Correspondents.

NORTH-EAST COAST.

The market has again sadly disappointed the hopes of improvement which were freely expressed a few weeks ago. It has relapsed into a state of idleness, and both prompt and forward business is at a very low ebb. Coking coal had a brief revival during the week, and an order was booked for Scandinavian gas-works, though at a price below current figures. Gas coal is very quiet, and in need of trade.

In face of difficulties, collieries are still making every effort to maintain quotations, with the result that there is a good deal of idle time. The one satisfactory feature is the coke market, in which all kinds have been in strong demand. Gas coke has been sold at round 20s. 6d. f.o.b. for prompt, and for forward positions, covering the autumn and winter, 21s. 6d. is reported to have been paid.

Nominal quotations remain unchanged. Wear Special gas makes ask 15s. 6d. f.o.b., and best qualities are 14s. 9d. to 15s. Seconds are 13s. 6d. to 13s. 9d. Durham unscreened coking is fairly steady at 13s. 6d. to 13s. 9d. Best bunkers ask 14s. 6d., seconds being plentiful at 13s. 3d. to 13s. 6d. Northumberland steams quote the minimum agreed prices of 13s. 6d. f.o.b. for best screened sorts downwards.

YORKSHIRE AND LANCASHIRE.

Gas coals are fairly normal, and prices so far do not appear to have moved upwards to the extent anticipated when the Five Counties Scheme was launched. It is expected, however, that the quota for July will show a reduction in the tonnage available for that month.

Industrial prices are fairly steady for the better qualities, though slacks, particularly those of a coking nature, are not in such request as they were a few weeks ago.

The domestic trade continues quiet, and collieries generally report stocks of screened house coal.

The following are the Humber bunker and export prices, f.o.b. usual shipping ports: South Yorkshire—Hards, Association, bunkers 17s. to 17s. 3d., export 14s. to 14s. 3d.; screened gas coal, 14s. 6d. to 15s. export; washed trebles, 14s. 6d. to 14s. 9d. export; washed doubles, 13s. 9d. to 14s. export; washed singles—bunkers 12s. 3d. to 12s. 6d.; export 13s. 3d. to 13s. 6d.; washed smalls, 10s. export; rough slack—bunkers 11s. 6d. to 11s. 9d.; smithy peas, 16s. 6d. to 17s. 6d. export.

West Yorkshire—Hartley's (f.o.b. Goole), 13s. 9d. to 14s.; screened gas coal, 14s.; washed trebles, 14s. to 14s. 3d.; washed doubles, 13s. 6d. to 13s. 9d.; washed singles, 13s. 3d. to 13s. 6d.; washed smalls, 9s. 6d. to 10s.; unwashed trebles, 14s.; unwashed doubles, 10s. 6d. to 11s.; rough slack, 8s. 6d. to 9s.; coking smalls, 7s. 6d. to 8s. 6d. all export.

Derbyshire and Nottinghamshire—Top hards, 16s. 6d. to 17s. 3d. bunkers and 14s. to 15s. export; washed doubles, 14s. export; washed singles, 13s. 6d. export; washed smalls, 12s. 3d. to 12s. 6d. bunkers and 10s. export; unwashed doubles, 10s. 6d. to 11s. 6d. export; rough slack, 11s. 6d. to 11s. 9d. bunkers and 9s. to 9s. 6d. export.

Yorkshire, Derbyshire, and Nottinghamshire—Screened steam coal, 15s. to 15s. 6d. bunkers and 12s. to 13s. export; gas coke, 21s. to 23s. export; furnace coke, 18s. 6d. to 19s. export; washed steam, 15s. 3d. to 15s. 6d. bunkers.

MIDLANDS.

Inducements are being offered to merchants and consumers to stock coals of suitable quality against winter requirements, a concession of about 1s. a ton being made off prices lately ruling. The collieries concerned state that the offer has been accepted quite as widely as they expected, substantial tonnages having been sold at the reduced rates.

These cases are exceptional, however, and relate to special grades of coal. The market position generally is unaffected. Coalowners who have been selling at a loss for months past do not see how the position would be bettered by making further sacrifices in the hope of stimulating a dead market. Collieries so favourably placed that they felt strong enough to remain outside the Five Counties Marketing Scheme are in some instances making almost a full output. At others employment is limited to two or three days a week.

Taking the Midland coalfields as a whole, the volume of business is not appreciably larger, though the freer functioning of the scheme for subsidizing exports is expected to mitigate competition in the inland centres as time goes on. Production is reported to be seriously unbalanced at some collieries which have a larger sale for parts of their output than they can satisfy under the restrictions of the quota. Those who distrust the principles on which the control is based admit that the working of the scheme in the first two or three months affords no fair test of its soundness. It is evident, however, that it has set up strains more severe than was foreseen by some who entered the Association.

GAS REGULATION ACT APPLICATIONS.

SECTION I.

Taunton Gas Light and Coke Company.

The Company seek an Order providing for the modification of the statutory or other provisions affecting the charges which may be made by them. The standard prices now authorized in respect of the supply of gas by the undertakers are 17d. and 18·2d. per therm; and the prices which they have asked the Board of Trade to substitute for these are 14·1d. and 15·3d. per therm.

SPECIAL ORDER.

Redhill Gas Company.

To change the name of the Company; to empower them to amalgamate with the Dorking Gas Company; to authorize the use of scheduled land; and for other purposes.

CONTRACTS OPEN.

Coal.

The Corporation of Middleton invite tenders for the supply of gas coal. [See advert. on p. 973.]

The Bakewell Urban District Council invite tenders for the supply of gas coal. [See advert. on p. 973.]

The Sutton-in-Ashfield Urban District Council invite tenders for the supply of gas coal. [See advert. on p. 974.]

Purifiers.

The Rotherham Gas Department invite tenders for the supply of purifiers. [See advert. on p. 974.]

Meters, &c.

The Birkenhead Corporation invite tenders for the supply of gas meters and fittings. [See advert. on p. 973.]

Gas Fittings, Paint, Oils, Iron, Tin, &c.

The Birkenhead Corporation invite tenders for the supply of the above, among other stores and materials. [See advert. on p. 973.]

Pipes and Fittings, &c.

The Birkenhead Corporation invite tenders for the supply of wrought-iron tubes and fittings, lead pipes, and cast-iron pipes and specials. [See advert. on p. 973.]

Compressor.

The Gas Committee of the City of Stoke-on-Trent invite tenders for the erection of a new compressor and the conversion of an existing compressor. [See advert. on p. 974.]

CURRENT SALES OF GAS PRODUCTS.

The London Market for Tar, Tar Products, and Sulphate.

LONDON, *June* 18.

The market in tar products continues quiet. Prices generally are about the same as a week ago.

Pitch is 65s. per ton.

Creosote is 8d. to 8¼d. per gallon.

Pure benzole is about 1s. 8d. per gallon; pure toluole, 2s. 1d. to 2s. 2d. per gallon; and 95/160 solvent naphtha, 1s. 6d. to 1s. 7d. per gallon.

Pyridine is 5s. 3d. to 5s. 6d. per gallon.

Tar Products in the Provinces.

June 18.

There has been little alteration in the market for tar products recently.

Pitch is quiet, and there is little or no demand from the Continent.

There is some inquiry from South Wales; but buyers are hoping to get on at something less than present quotations. There does not appear to be any pressure on the part of manufacturers to sell. Creosote oil is steady, and there is rather more inquiry both for home consumption and for export.

Water-white products are firm and in good demand.

Crude carbolic is quite steady, and there are buyers to the end of the year at ruling prices.

Tar acids are quieter. Cresylic is a little easier; but makers have not reduced their prices.

Naphthalene is firm, and there is still a fair amount of inquiry.

The average prices of gas-works products during the week were: Gas-works tar, 42s. 6d. to 47s. 6d. Pitch—East Coast, 60s. to 62s. 6d. f.o.b. West Coast—Manchester, 54s. to 55s.; Liverpool, 56s. 6d. to 57s. 6d.; Clyde, 55s. to 57s. 6d. Toluole, Naked, North, 1s. 5d. to 1s. 6d. nominal. Coal-tar crude naphtha, in bulk, North, 9d. to 10d. Solvent naphtha, naked, North, 1s. 1½d. to 1s. 2d. Heavy naphtha, North, 1s. to 1s. 0½d. Creosote, in bulk, North, liquid, 6¼d. to 6½d.; salty, 6¼d. to 6⅝d.; Scotland, 6½d. to 6⅝d. Heavy oils, in bulk, North, 8¼d. to 8½d. Carbolic acid, 60 p.ct., 2s. 3d. to 2s. 4d. prompt. Naphthalene, £13 to £15; salts, £5 to £5 10s., bags included. Anthracene, "A" quality, 2½d. per minimum 40 p.ct., purely nominal; "B" quality, unsaleable.

Benzole Prices.

The following are considered to be the market prices to-day:

	s. d.		s. d.	
Crude benzole . . .	0 10½	to	0 11	per gallon at works
Motor ,, . . .	1 4½	,, 1 5	,,	,,
90 p.ct. ,, . . .	1 7	,, 1 8	,,	,,
Pure ,, . . .	1 10	,, 1 11	,,	,,

Cheaper Gas at Carlisle.—The Carlisle Gas Committee have decided to reduce the price of gas from 3s. 6d. to 3s. 3d. per 1000 c.ft. The net profit for the year amounted to £10,615.

Reductions in Price at Much Wenlock and Ellesmere.—The Much Wenlock Urban District Council have decided to reduce the price of gas from 6s. 8d. to 6s. per 1000 c.ft. from July 1 next; and the Ellesmere Urban District Council have agreed to reduce the price to 6s. 8d. per 1000 c.ft. as from the end of the June quarter.

Nelson Gas Accounts.—In his ninth annual report on the work done and the results obtained in the Nelson Gas Department during the year ended March 31, Mr. James Mitchell, the Engineer and General Manager, states that the net profit is £17,950. The total quantity of gas delivered during the year was 576,161,000 c.ft., being a decrease of 32,408,000 c.ft., or 5·32 p.ct., on the quantity delivered last year. There are now 16,763 consumers, 6642 of whom have ordinary meters, and 10,121 prepayment meters. This figure is an increase of 338 consumers during the year. The average consumption per ordinary meter was 32,671 c.ft, and that per prepayment meter 27,732 c.ft.

New Carbonizing Plant at Silsden.—An inquiry on behalf of the Ministry of Health was held at Silsden on June 15, into an application by the Silsden Urban District Council for power to borrow £9200 for new carbonizing plant at the gas-works.

Ashbourne Gas Charges.—The Ashbourne Urban Council have decided to reduce the price of gas to ordinary and prepayment meter consumers by 2d. per 1000 c.ft. by increasing the discounts allowed per quarter, providing accounts are paid within a month.

Reduction in Price of Gas at Blairgowrie.—The Directors of the Blairgowrie Gaslight Company have decided to reduce the price of gas by 3d. per 1000 c.ft., the reduction to take effect from the last survey of the meters. The price is now 6s. 6d. Gas for power has been reduced by 9d. per 1000 c.ft.

Excellent Publicity at Deal.—In the "Deal, Walmer, and Sandwich Mercury" for June 16 appeared an illustrated article entitled "A Visit to the Deal Gas-Works." In this it is explained that during the past few weeks visits to the gas-works have been made by parties from various schools in the district.

Reduction in Gas Prices at Deal.—The Directors of the Deal and Walmer Gas Company have reduced the price of gas by ⅜d. per therm, to 10·4d. For ordinary meter consumers, the reduction will take effect at and from the meter readings for the June quarter, and for prepayment consumers at and from the first reading and collection following June 30.

Extensions at Meltham.—A Ministry of Health inquiry was held at Meltham, near Huddersfield, on June 14, into the application of the Meltham Urban District Council for sanction to borrow £2221 for a new gasholder and £1000 for plant extensions at the gas-works. It was stated there had been much complaint of lack of pressure, and the Council aimed to overcome that problem.

Progress at Workington.—In moving the adoption of the Gas Committee's annual report at a recent meeting of the Workington Town Council, Alderman F. Hall said that the net profit was £3777, which it was proposed to carry to the reserve for renewals. It was proposed to reduce the price of gas inside the Borough, as from the June indexing of the meters, from 3s. 5d. to 3s. 2d. per 1000 c.ft. through ordinary meters, and to give 24 c.ft. per 1d. to prepayment consumers. Corresponding reductions would be made in the prices of gas outside the Borough. In his report, Mr. Hedley Hoy, the Engineer and Manager, stated that the net return from the sale of residuals was 51·46 p.ct. of the cost of coal, and the average annual gas consumption per ordinary meter was 39,142 c.ft. The total gas sold showed an increase over the corresponding figure for 1926-27.

Arbroath Gas-Works Profit.—The financial result of last year's working of the Arbroath Gas-Works shows a gross profit of £13,722. At a meeting of the Town Council, the report of Mr. A. C. Young, the Gas Manager, showed that the gas sold, *less* street lighting, was increased by just over 3½ million c.ft. From the gross profit of £13,722 was to be deducted a debit balance carried forward from last year of £7293. After the sum of £6398 had been paid towards sinking fund, contingency and depreciation account, &c., there would be a credit balance at the end of the year of £30. It was recommended that the price of gas be reduced from 3s. 6d. to 3s. 2d. per 1000 c.ft. to ordinary consumers, and from 3s. 10d. to 3s. 6d. per 1000 c.ft. to prepayment meter consumers, and that the existing allowances for gas engines and discounts to large consumers be continued. The prices were fixed as recommended.

Results at Lincoln.—In moving the adoption, at the last meeting of the Lincoln Town Council, of the annual report of the Gas Committee, of which he is Chairman, Alderman T. Wallis observed that the accounts showed very satisfactory results in relation to last year's operations, when the conditions prevailing during that period were taken into consideration. They disclosed a net profit of £11,189, which had been carried forward to the reserve fund. The year had been responsible for an exceptional expenditure on new works, mains, &c., amounting to £14,590. Though more than £10,000 of that could have been met by obtaining an Order to borrow the sum, and for which the authority of the Council had been sanctioned, it had been paid for out of the reserve fund, reducing the balance in that fund to £966. That expenditure, he reminded the Council, would be of a remunerative character, and the early return of it would much more than balance any interest charges by banks on overdraft as a result of such expenditure. There had been a considerable increase during the past year in the quantity of gas sold and the number of consumers. His Committee agreed to recommend a reduction in the price of gas of 3d. per 1000 c.ft., to take place on Sept. 30. The Committee's report was adopted.

The make of gas at Kirkintilloch last year was 153 million c.ft. —an increase of 4½ millions.

The Helensburgh Gas Commissioners have placed an order for a new gasholder of a capacity of 500,000 c.ft.

The Goole Urban District Council, on June 14, agreed to reduce the charge for gas forthwith from 4s. to 3s. 6d. per 1000 c.ft.

The Buckie Gas Light Company have reduced the price of gas by 5d. per 1000 c.ft. The charges now are 6s. 3d. for lighting and 5s. 10d. for heat and power.

The Bradford Corporation Gas Committee have agreed, as in previous years, to allocate the sum of £10 for the provision of prizes to be awarded locally in connection with the school-children's competition organized by the British Commercal Gas Association.

Fifty members of the Spen Valley Trades and Labour Council recently paid a visit of inspection to the gas-works of the Spenborough Urban District Council. They were accompanied by Lieut.-Col. H. S. Atkinson, Chairman of the Gas Committee; and the processes of gas manufacture and extraction of residuals were explained by Mr. A. L. Jennings, the Gas Engineer and General Manager.